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THE Journal this month issues with a new cover, for which we are indebted to the artistic skill of Mr. R. Cecil Wood, Principal of the Agricultural College and Research Institute, Coimbatore.

J. MACKENNA,

Agricultural Adviser to the Government of India.

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Woodhouse-Southern Memorial

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HIS EXCELLENCY THE RIGHT HON'BLE LORD PENTLAND,
P.C., G. C. S. I., G. C. I. E.
Governor of Madras.

Woodhouse-Southern Memorial

Dulce et decorum est pro patriâ mori

E. J. Woodhouse, M.A., F.L.S.,

Economic Botanist to the Government of Bihar and Orissa.

Born, 15th November, 1884. Died of wounds in France, 18th December, 1917.

* * * * *

Hugh Southern, M.A.,

Deputy Director of Agriculture, Punjab.

Born, 17th January, 1886. Reported missing, April 1916, and officially declared to be dead, July 1918.

The Moon of Peace has risen midst the dark clouds of War and dispelled the gloom which has so long prevailed. But in the case of two members of our department the words of Omar may not inappropriately be applied--

" The Moon of Heav'n is rising once again :
" How oft hereafter rising shall she look
" Through this same Garden after me—in vain ! "

Of the members of the department who went forth to fight their country's battles two have made the supreme sacrifice and will not return to us. Woodhouse sleeps his last sleep in the West: the grave of Hugh Southern "no man knoweth."

Now that hostilities are over, I am sure that members of the department and other friends will wish to perpetuate the memory of these young officers. I propose therefore to open a subscription List with a view to establishing in the Lyallpur and Sabour Agricultural Colleges memorial prizes bearing the names of the fallen officers. Personally I favour a general contribution, to be divided equally between the two colleges, but if subscribers prefer, their donations will be allotted to a particular college.

Donations should be forwarded to me at Pusa and will be acknowledged in the Journal.

Original Articles.

MATERIALS FOR A POLICY OF AGRICULTURAL EDUCATION.

BY

H. M. LEAKE, M.A., F.L.S.,

Economic Botanist to the Government and Principal, Agricultural College, Cawnpore.

> Myself when young did eagerly frequent
> Doctor and Saint and heard great Argument
> About it and about: but evermore
> Came out by the same Door as in I went.

In perusing the voluminous literature which has arisen on subjects educational, the quotation which heads this paper comes somewhat forcibly to the mind. I am not oblivious to the retort that this statement obviously raises, namely, why then add to that volume? I have failed to find an answer which satisfies myself, and am fain to admit that it is probably of the same tenor as that to the riddle of our childhood—the riddle I do not remember, but the answer was to the effect that the other donkey did so too. There are certain thoughts, however—perhaps more suitably termed criticisms—which so constantly arise in such perusals that I am tempted to assume the rôle of the other donkey and commence with a few general observations which will lead on to the more special subject of agricultural education.

In all educational institutions we have two factors—the pupil and the teacher; the former, owing to the system of teaching in classes, a multiple, the latter a single, intelligence. This condition too often offers the mental equivalent of a boat's crew. In training

a crew for a race the coach has to think of the crew as a whole and attempt to raise the average physical fitness to the highest point on the day of the race. For this purpose certain members will be over-trained or "stale," others under-trained. The system of training, consisting as it does, or did in my own college days, of combined exercise in the boat, and individual exercise, known technically as swinging, affords a certain amount of latitude in adapting this system to the individual capacities of the oarsmen. Add to this the fact that the rowing age is an age of discretion where the oarsman is capable of interpreting his own feelings and expressing them to the coach, and it becomes clear that the training for a race is a system interpreted by a coach, or teacher, who is aided and checked by the intelligences of the individual members of his crew. The similarity of the conditions of the teacher with his class, to those of the coach with his crew, is sufficiently near to mask the essential and great differences, and this similarity is emphasized by the examination system which fixes a culminating point for the education. For, just as the crew is judged by the result of the race, and as the coach attempts to have his crew in the pink of condition on the day the race is rowed, so the teacher attempts to have his class so mentally equipped on the day of the examination that it will show the best advantage. To do this he, too, adopts a system and, to the extent that the class system, by which the pupils are distributed to him, and the examination system, by which he and his pupils are judged, become standardized, that system also becomes standardized and impersonal.

The force of the comparison, however, lies not so much in the points of similarity as in the differences, and this aspect will repay a brief consideration. The crew is judged by its combined effort which is the resultant of the individual efficiencies of the members of the crew. In the case of the examination, on the other hand, there is no combined effort—the individual efficiencies are not interdependent—and the teacher will be judged differently according as major stress is laid on the average number of passes or on the standard attained by the most intelligent pupils. This difference may be expressed in another way. While the judge at the winning

post of the boat race has no personal influence on the result of the race and, through it, on the coach and the system of training, the judge in the examination, in other words, the examiner, according as he frames his questions and considers the answers to test the general standard of the class or to pick out the best pupils, will have a material influence on the teacher and his system of teaching. Of the former type, the examinations, as conducted in this country, are perhaps the most typical examples, while, of the latter, the scholarship examinations, as conducted at the older English universities, afford a good illustration. The former appear to be the sounder in that it will aim at the maintenance of an average standard of the combined teaching, within the understanding of all the students, about which individual exercises, adapted to the individual intelligences, can be built. The latter type of examination forces the standard of the combined teaching to the level of the highest intelligence—too far above the level of the weaker intellects for any system of individual exercise to be of value.

Again, I have stated the members of the crew have reached an age of discretion. They are in a position to judge by their feelings their physical fitness; they can convey those feelings to the coach who can modify the individual training accordingly. The pupil is in no such enviable position. He is not a judge of his own mental condition and the teacher is, thus, to this extent at a disadvantage, when compared with the coach, that he has to interpret his instruction in terms, not of his own intelligence, but of that of his pupils. This to my mind is a point rarely realized and realized with the utmost difficulty. Again and again I have listened to reasoned and logical arguments on courses of instruction the reason and logic of which, however, appeals to the adult mind, and I have found it impossible to avoid wondering, as I listened, whether the speaker had not assumed in his pupils a mind as logical and as accustomed to reasoning as his own. The danger is, in fact, very real that, in evolving a system which is reasoned and logical, the teacher is evolving one which, by that very fact that it is reasoned and logical, will appeal to the adult and not the pupil mind. He has, in fact, failed in one of the main functions of a teacher, and he

lacks the capacity of projecting himself into the position of the pupil.

There is yet a third difference in the comparison I have drawn. The coach's efforts are concentrated on the race and on turning out his crew on the day in a condition as near physical perfection as possible. It is no concern of his if, on the evening after the race, the stroke dines not wisely but too well, and is later arrested for obstructing the police; nor does he care if another member of the crew spends the rest of the day smoking till he becomes ill. The teacher is in a totally different position with his pupil. He does not, or should not, lose interest in his pupil on the day the examination result is published, though this is perhaps too frequently the case. A teacher who does this is not worthy of the post, and it is only necessary to consider one of the objects of education, and that is, to render the individual a useful citizen, to make this clear. Education has missed one of its main functions if it will not prevent the man who successfully passes the final examination from developing into a pick-pocket.

By the above comparison I have attempted to bring into prominence one aspect of the educational problem, and one which is frequently overlooked, namely, the insignificance of the system compared with the individual. My statement that this aspect is overlooked may be called in question, and it is true that recognition is frequently accorded to the point. I cannot help thinking, on the other hand, that, in this country, as in others, in the distribution of educational finance and in the grants lavished by Government for educational development, which are largely earmarked as non-recurring and are devoted to the erection of new school buildings, too much attention is given to the numbers of schools teaching a standard curriculum, and too little to that improvement of the pay and prospects of the teachers which alone will attract a better class to the profession and thus remove the necessity for that rigid standardization which stultifies the individual initiative— so essential to real education—of the teacher.

The above considerations are of general application; that is, they apply to the educational problems of any country, but from

this point my argument proceeds along two lines, and deals more particularly with the problem as it appears in this country. The first of these deals with the type of education, as influenced by the conditions of the country, the second with the limitations imposed by the system of educational finance.

One of the functions of education has been already stated, namely, to render the individual a useful citizen. That may be a highly materialistic aspect, but the modern world is materialistic, and a country, if it is not to be left behind in the international race, must be materialistic. It is difficult, if not impossible, to find a brief definition which will cover each and every function of education, and the above will, perhaps, serve as well as any for a starting point. Now it is obvious that the world would not be a satisfactory place to live in, if everyone were educated to the clerical profession. The clerk is a useful person, but once the number exceeds that necessary to carry on the essential clerical work, there must be a number of persons who are failing to fulfil that function. It may be that there is here a confusion between education and training, but I think not, though I admit the line of demarcation between the two is not readily drawn. Education then, considered from a national aspect, must be diverse, and, in its practical aspect, consists in placing before the youth of the country the essentials for the development of the mind in a form which will leave the individual in a condition in which he will render useful service as a citizen. In former times the guiding factor in the choice of a profession was mainly parentage, the son following the trade of the father, and this is still very largely the case, especially in more backward countries. But modern thought the result of compulsory education-- is increasingly in favour of equality of chance, irrespective of birth. Within wide limits, therefore, the diversity of education should be so disposed as to place within reach of each individual a form of education suited to his probable future life. A more detailed consideration of the true meaning of this statement is desirable, since it is here, I think, that the fallacy contained in the modern claim for equality of chance, and in the various economic doctrines arising therefrom, is most readily exposed.

In the various professions by which the individual earns a livelihood, the labour expended is rewarded in very different measure in the apportionment of worldly goods, and, with the materialistic aspect of modern life, the professions tend to be judged by this standard and to be desirable in proportion to the measure of these goods received. Equality of chance in practice, therefore, implies a claim on the part of every individual to an education fitting him for the most lucrative profession. Now it is perfectly clear that the world would not be a fit place to live in if every individual were educated for the legal profession. Food and the thousand necessities of modern life have to be produced by human labour, and for that labour the education I have taken, as example, is unsuited. Equality of chance, therefore, is not obtainable by the provision of an education qualifying for the most lucrative fields of employment. The alternative, the equalizing of the reward, while perhaps not theoretically unsound, is practically unattainable. It is only necessary to attempt to picture the economic condition of a country in which the farm labourer receives, say, Rs. 1,000 per mensem,* to understand how far we are from obtaining equality of chance by this means. The fact is, such equality is an ideal, probably undesirable and, certainly, practically unobtainable. Labour of the brain always has been, and will continue to be, more liberally rewarded than labour of the hands, though change may occur in the degree of divergence. Equality of chance is, thus, a fallacy; nevertheless the idea has an underlying basis of truth. That truth is, I think, this. While, for the majority, it is desirable that an education shall be provided which will fit them to fill the station they are most likely to occupy in life, namely, that into which they are born, modern thought demands, and rightly demands, that the individual should not be bound by the accident of birth. Far from this meaning that each individual has a claim to the highest form of education, it implies that a ladder should exist by which individuals in any particular station can ascend, if so fitted, to a

* The same condition will be reached by assuming the High Court Judge to be paid Rs. 7 per mensem, the essential fact being the relation between cost of production and purchasing capacity—that is, relative, and not absolute, values.

higher one. Advancement is, thus, not an inherent right, but the reward of merit. One error running through educational discussions and educational schemes is the misplacement of these two objects of education –the conversion of the ladder provided for the gifted to a broad staircase for the mediocre. The effect of this error is to be seen in most countries, but in none, perhaps, more so than in this. The average individual is led to expect, regardless of economic laws, an education fitting him for a station into which he was not born and, in after life, a remunerative field in that station. The inevitable result is disillusion and discontent, the source of half the social unrest in this and most advancing countries.

I think we have now reached a stage in the argument which will enable us to provide a truer view of educational aim. It is that the main, and major, educational object should be to provide an education which will leave the individual a useful citizen in the sphere in which he was born. The educational ideal, contained in the above, is to inculcate in each individual that habit which is briefly and succinctly given in the catechismal saying, "to learn and labour truly to get my own living and to do my duty in that stage of life into which it shall please God to call me."* It may be argued that that attitude is incompatible with ambition, the desire to ascend, but I think not. That desire may exist alongside the ready acceptance of the fact of failure. But while I insist that this ideal should form the main object of educational policy, I am equally certain that that object will only be completed by the provision of what has been termed a ladder, but a ladder so hedged about that only those suitably equipped may ascend.

If the arguments adduced are sound, it follows that in any country the type of education most commonly found, should be

*** "To do your work honestly, to die when your time comes and go hence with as clean a breast as may be—may these be all yours and ours by God's will. Let us be content with our status, telling the truth as far as may be, filling not a very lofty but a manly and honourable part."**

In turning over the pages of Thackeray's "Essays and Reviews" during an idle half hour I have, since this article went to the press, chanced to light on the passage above quoted. It is one which would be hard to equal as a definition of the educational ideal.

adapted to fit individuals for the occupation most commonly practised, and it is only necessary to glance at the figures to appreciate how far education in this country is from the ideal I have outlined.

In the United Provinces "two-thirds of the population are supported by agriculture, and there is no single occupation which supports one-tenth of this number of people." In actual figures these are divisible into the following main classes :—

Zemindars, non-cultivating	500,000
" cultivating	3,000,000
Tenants with some occupancy rights	10,500,000
" " no occupancy rights	10,250,000
Sub-tenants	2,000,000
Labourers	4,500,000
TOTAL ...	30,750,000

While the latter two roughly constitute a class whose standard of living is such that the children have to begin to take a share in the family labours at a very early age, and for whom, therefore, the simplest primary education is all that can be provided, a very large proportion of the remainder occupy a position, such that the children are not compelled to earn a livelihood till the age of 17 or even later, and for whom it is desirable, both on individual and communistic grounds, to provide an education fulfilling the conditions I have laid down. I have said on individual and communistic grounds—individual, because the world's progress is affecting agriculture equally with other occupations, and that man will succeed best who most clearly appreciates this progress and most quickly profits by new markets opened to him; communistic, because sound development of a community is only obtained by equality in the rate of educational progress of its several component parts, the unsoundest form of development being that where a small minority progresses while the bulk of the population stagnates.

There is thus a large community, probably larger than any other single community of the province, in a position to benefit by a suitable form of agricultural education. This state may be compared with the educational facilities provided, and in doing so care must be taken to distinguish between teaching agriculture, and education

fitting the student to return to the land. The point need hardly be laboured; the literary nature of the mass of the secondary education, unfitting the student for practical work of any nature; the location of the schools in urban surroundings, accustoming the student to a social life he cannot obtain at his home and replacing the healthy out-door life of the individual by the artificial sports of the play-ground of which, though a true admirer, I recognize the limitations which include a dependence on companions for the supply of his physical recreations - are too well known to require further development. It is true attempts have been made to introduce agriculture into the school curriculum. These, however, come to grief from failure to distinguish between teaching agriculture and supplying an education suiting the pupil to return to the land. It is not realized that the student truly from an agricultural stock knows a great deal about practical agriculture, usually a good deal more than the master provided under such conditions to teach it, and such attempts as have been made hitherto to rectify the educational deficiencies indicated have failed from this cause.

On the first line of my argument, therefore, we have arrived at the conclusion that the present educational system totally fails to satisfy the needs of the largest single element, if not the major portion, of the community. It is true there is an agricultural college, but that is a coping stone without the underlying structure. Moreover, the position of a college will be more clearly understood when the second line of argument has been developed.

Educational effort, like every form of endeavour, is limited by financial considerations. The necessary funds are obtained in a variety of ways. In many cases, as in the older universities and public schools of England, the funds arise from endowments, a system well illustrated by the munificent gifts which have been made for education in the United States. In others, of which the primary educational institutions of England and a large proportion of those of this country are examples, the funds are provided by Government. In the former case the trustees are the sole arbiters in any question as to the disposal of the available funds, and the primary consideration is the degree to which the founders' terms

are complied with. In these cases, there is no question of a financial return, the trust is complete with the fulfilment of the conditions imposed. Where, however, the funds are provided by Government the position is different. Government is merely in the position of trustee for the country, and it is its duty to see that the country receives the fullest measure of return for the expenditure involved. It is no part of my argument to justify the expenditure of public funds on education, that is generally admitted; my concern is with the measure of the return received, with relative, rather than with absolute, values. There can be little doubt of the relative value of the two classes of education; that which, on the average, fits a man for full development in that station in which he lives and has his being, and that which compels him to seek, among fresh fields and pastures new to him, his means of livelihood. The former is a process of gradual evolution of the individual, which allows for development owing to the gradual interaction between the individual and his surroundings; the latter partakes of the nature of thrusting hot glass into cold water, a process ending usually in the destruction of the glass vessel.

The true error in the educational system of this country, as I conceive it, lies in the fact that it has hitherto developed along lines which render it unsuited for the largest single element, if not for the major portion, of the population. This is no complaint that the educational facilities are excessive, but it is a very definite statement that the fullest measure is not being obtained for the funds expended. This is not merely based on negative considerations implying merely a waste of funds, such would be the case if the schools and colleges were filled by the sons of the clerical and learned professions; it implies more than this, the expenditure of funds on directions actively harmful; for, by failing to provide an education fitting the son of the landholder to remain on the land, the system drives such persons into a line of life for which they are unfitted, and in entering which they become as the hot glass to cold water. What is needed, and urgently needed, is the development of a form of education which will leave the average country youth fitted for life in the surroundings in which he is

born; there is ample scope in such surroundings for the educated mind to find full and useful employment and to fulfil the rôle of a useful citizen which we have laid down to be one of the main functions of education.

It is open to argument that I am here labouring to prove a point, the importance of which is already sufficiently recognized. In part that is true; the recent conferences on agricultural education, the first held two years ago at Pusa, and the second last year at Simla, indicate this. The "memorandum showing what has been or is being done to impart agricultural education to the sons of cultivators," published in connection with the report of the last conference, however, shows what a relatively small amount of effort has been devoted to this aspect of education. Nor is my main object to supply this proof. I am tempted to think the difficulty has lain not so much in the recognition of the fact as in the recognition of what constitutes a suitable form of education. The arguments I have hitherto adduced may incidentally prove this point, but that proof is only incidental. Their main advantage lies in the fact that they provide a point of view which will, I think, help to point a way to a solution of some at least of the practical difficulties involved.

I have tried to show that, at least where the funds are provided from public sources, there is a very definite financial limitation to the method of disposal. This will become clearer on considering a concrete case. The Cawnpore Agricultural College has a four years' diploma course limited to 25 students per year, or a total of 100 students in residence. The college budget is Rs. 43,600, but this is clearly an under-charge, as it excludes all charges on the botanical and chemical sides, which are budgetted jointly with research, and it is merely the recurring charge without allowance for interest on capital charges or depreciation on building accounts. It is probable a figure of three-fourths of a lakh is not an over-estimate—that is, a cost of Rs. 750 per annum per student. The question is, under what circumstances is the expenditure of this sum of public money justified? It is always difficult to argue with any degree of conviction as to the justification of expenditure where the return is,

as in this case, indirect. The subject is, therefore, best approached from a different aspect, and there are two such. The first is to discover the circumstances under which that return will be a maximum, and the second to consider the class of applicant now seeking admission.

The justification of the Agricultural Department must be found, in like manner, in the improvement of the economic conditions of the country, and no doubt the expenditure on the college is justified to some extent by the necessity of training members for that department. That, however, is a minor matter, two only, out of the 25 students annually admitted, being admitted to the service. Were that the only object of the college, it would appear possible to find a more economical method of recruitment. The truth is that the ultimate justification must be found in the future career of the 23 remaining students.

Now, considered in a relative aspect, it cannot be doubted that a single zemindar, possessor of several villages, who takes a personal interest in his estate and who is progressive, by reason of a liberal education such as the college is now in a position to give, is potentially a far greater asset to the country than the small zemindar or tenant cultivating a few *bighas*. In the former case the gain is not limited to the actual money value of the better crops produced, and of the extra gain due to better business methods, great though this may be. His property forms a practical demonstration which must have some influence on the surrounding countryside, and he himself becomes an unpaid propagandist of new methods. The latter, on the contrary, can do little more than grow better and more valuable crops, and he possesses little of that which we may briefly sum up as influence. The college will be filling its function to the full, therefore, only when the main source of recruitment is the zemindar class, a class relatively small, perhaps, but numerically large and potentially powerful. It can hardly be doubted that a college with students so recruited would be in a position to do more to improve agriculture and the economic conditions of the countryside, on which that improvement so largely depends, than one with students recruited from any other source. It is

the condition in which the college will most fully justify its existence.

That, at least, is the aim I have set before myself since I have been in charge of the college at Cawnpore. It is, for many reasons, an aim not immediately realizable. The larger landholders are mostly non-resident and have more immediate interests. The smaller ones are shy and frequently insufficiently educated. For the present it is sufficient if a few only of this class come, and it is a hopeful sign that this is the case.

The majority of applicants at the present time are, nevertheless, men merely seeking Government appointment intermixed with true agriculturists, petty zemindars or tenants. Frequently the application is accompanied by an appeal for a stipend. With the former I have no concern, they are not the type of student for whom there is any opening. The latter, however, form the class to which the department looks for its recruits and the admission of a few is justified on this ground. The claim for a stipend is a different matter, and as it is here that the financial aspect receives its clearest demonstration a short digression will not be amiss.

To any one who has had to deal with the selection of students for admission to a college the frequency with which poverty, as a ground for admission accompanied by financial assistance, is advanced will be well known. The fallacy of such a claim has, as far as I am aware, never been shown up: it is certainly not generally recognized. What applies for one applies to all. Were poverty to constitute in one case a claim to admission to a college with a stipend, every youth of suitable age would be justified in demanding this concession, and the collegiate education would become the standard the State is called upon to provide. The cost, placed at Rs. 750 per annum in the case of the college, to the State is clearly prohibitive, and those persons who advance such a claim forget that the money to provide the education and stipends ultimately comes from their own pockets. The fact is that stipends are only justified in cases where poverty appears as a check to an ability, to the possessor of which a college course will open a useful and profitable career.

I have now attempted to define, by reference to the Cawnpore College, the legitimate function of such an institution. That function is, to a certain extent, based on local conditions, and is not, therefore, necessarily identical with that of other colleges. The same financial consideration, however, underlies all, and the college aspect can never do more than touch on the fringe of the problem, reaching as it does only the numerically smallest class of persons connected with the land. If the true function is performed, however, the college will be the means of providing, in the departmental district officers and in the progressive zemindar, two agencies of effective agricultural development. The speed of introduction of improved methods is, however, a reciprocal process dependent not only on the skill and energy of the instructor, but on the receptivity of the instructed. While, therefore, the college is providing for the former, the latter is in no way provided for. The form of education provided is too expensive for the mass, it is moreover collegiate.* What is here required is a cheap form of secondary education, complete in itself and complete within the limits provided by the age at which the average boy leaves school. In the United Provinces the sole attempt hitherto to provide an education of this type is in the vernacular two years' course of the college. The institution of this course and its location at the college is admittedly a temporary arrangement and the course suffers from many disadvantages. In the first place, the age of admission is too high for a true secondary school, being the same as for the four years' diploma, or collegiate, course. Secondly, in addition to supplying a course of instruction suited for the class which we are now considering, it attempts to meet the needs of the members of that class which I have shown the college should attract, but those members who possess insufficient knowledge of English to take that course, two aims which are incompatible. While, therefore, the course has not been without its uses, it fails in several directions to meet the needs of the situation. In other provinces greatest progress in attempts

* Or should be. Owing to the weakness of the secondary education, the teaching has to make up the deficiency and is largely secondary in character.

to solve the problem has, perhaps, been made in the Bombay Presidency where several vernacular agricultural schools are in existence. The cost of each pupil is stated to be Rs. 180 per annum, grounds which alone would place it beyond consideration for universal adoption.* The main problem, the provision of schools supplying an education fitted to the needs of the mass of the agricultural population and at a cost which makes possible their establishment in numbers sufficient for the accommodation of the available pupils, still awaits solution.

The primary object of such schools will be to raise the receptivity of the younger generation of agriculturists and the method of attainment must be through education under conditions which retain the association with the land. This is a very different proposition to the provision of vocational schools, of which the main function is to impart technical skill. In the latter, technical instruction is the primary consideration, and theory is only taught in so far as it bears on the particular trade. In the former, it is true, subjects bearing on the vocation may, and do, form part of the course, but the centre of gravity of the instruction is shifted. These subjects are taught for their internal value as a means of education, and the practical application is left to be drawn by a process of natural imbibition in the daily life. It is here, as I think, that the efforts which have been made to introduce agriculture into the existing schools have failed.

Let us consider for a moment how an agricultural school of this type would be organized. The courses of instruction are to be educational and the students are to be introduced to an appreciation of a standard of country life, something superior to the ordinary village life they have known, by a process of familiarity. Although, therefore, not directly a part of the education, the conditions and their arrangement will form as, if not a more important section of the school organization than the purely educational section, in that they will form an essential of all such institutions, while modification

* A boarding secondary school of the present type costs approximately Rs. 60 per annum for each pupil.

to suit the different grades of schools will be made in the educational courses.

I will try and bring out the main features of such an organization by a description of such a school as I conceive it. It is to offer a practical demonstration of village life under improved conditions, under which the student will live and have his being with a degree of intimacy that will render those conditions a normal part of his existence. Now the essence of village life is the family, living as a unit cultivating a certain area—greater or less according, in part, to the circumstances of the family, but, in part, also, according to the locality. Thus the holdings in the east are, on the average, much smaller than those in the west of the provinces, and allowance will have to be made for such divergencies. The school will now represent a village, the unit of communal life, composed of families, the unit of private life. Assuming a middle school with a five years' course and the maximum age 17 or 18, the students of the senior class will each represent the heads of the families which will be made up of, roughly, one student from each year, giving in all five members to each family. The school will have approximately sufficient land to provide for each "family" of five students an area, roughly, equal to the average holding of the locality. In this community the headmaster and his assistants will play the rôle of the zemindar and his agents. He will apportion the farm lands among the "families," issuing yearly leases at reasonable rents, and the "family" will then cultivate the land under his directions, actually performing the operations themselves. The next year a rearrangement of students in the "family" necessitated by the head leaving and by the introduction of new admissions, combined with a redistribution of leases, will give ample opportunity for arranging that each student will obtain practical experience, during his period of residence of each of the crops cultivated.

Before passing to the strictly educational aspect of the course, we may consider this proposal in some further detail. I have said the headmaster will play the rôle of zemindar; he will, if the scheme is to attain its full development, have to play many parts. As zemindar, I have stated, he will issue leases at reasonable rents.

It is not proposed that these rents should necessarily be paid. The headmaster should also organize the school as a co-operative society, of which the individual heads of families are members and from which the rent can be advanced. Reality can be given by the payment of a nominal sum by each "head" for membership, but the rent and most other transactions, being dues to the headmaster, may be book entries merely. Produce would be similarly pooled for disposal on co-operative principles and may even be used to supply a co-operative store to supply the necessaries of life of the students. If payment be actually made by each student or by each "head," a nominal bonus may be given, otherwise the transactions will, throughout, be nominal as regards cash values, but in all respects should conform with reality. Thus, the amount shown to the credit of a "family" for produce received should be based on the actual sum for which the produce was disposed.

The above constitutes what I may term the environmental aspect of the school; the educational aspect may now be considered. This is an aspect which, more than any other, suffers from the danger of dogma, and, in the present case, it in no way differs from the general problem as it appears in all educational institutions. It is a problem to which each individual will offer a different solution depending on his particular personal bent. Such solution as I shall offer is, therefore, of necessity so coloured. Education as found in this country fails in two directions—the first, practicality; the second, accuracy. With the former I have already dealt; the whole organization of the environment is aimed at developing this character. The latter must be developed in the class-room. For this purpose the following subjects seem best fitted: mathematics, associated with which may be book-keeping and accounts, and elementary physics. With these subjects emphasized, the remainder of the course will be composed of those subjects which form the basis of the curriculum of the ordinary school, preference being given to subjects which have some association with the life the students lead. Care, however, must be taken to teach each as a balanced subject without undue prominence given to their supposed practical aspects. Among such subjects I should place English, geography,

physiography and elementary studies of plant life. In the above course—and it is not desirable to go into greater detail at present—my main object being to develop principles rather than detailed schemes, the only direct point of contact between the environmental and educational sides of the school lies in the accounts, for which the books of the institution may well be used to provide practical examples. A comparison of this outline with, for instance, the curriculum of the Loni School, will bring into prominence the difference I have tried to emphasize.

A pupil taking five years to pass through such a course would thus gradually imbibe the practical aspect of agriculture; would be gradually introduced to those conditions which tend to place the cultivator in a position of sturdy independence and self-reliance, and should, by the end of his school career, be fitted to return to his home and the reality of life with a sense educated to realize the more backward conditions and a will to remedy them—a condition of mind and body suggestive of a career as a useful citizen. The information will, moreover, be learnt by a process of absorption from constant association, one of the essential conditions if the soundness of my contention is admitted.

There remains the question of cost, the question whether the scheme will satisfy the second or financial consideration, which it must do if it is to justify the expenditure of public funds involved. With 30 students in each class, a school of 150 will be formed for which an area of 150 acres' cultivation will be required if each holding is calculated at 5 acres. As most of the labour will be provided by the students, the labour bill will be small and the profit on cost of production should be considerable. In addition, there will be the capital charges and the cost of instructional staff. The former will be larger, but the latter not necessarily greater than the same charges of a school of the same standing but of the usual type. The unknown factors at the present stage are too numerous to make it possible to draw up a balance sheet which would approach any degree of probability to the actual, but it seems more than probable that the cost would be, on the balance, low. One point at any rate is clear; unless the farm is working at a profit, and a handsome

profit, it will not be fulfilling its function, and we have here, therefore, a very simple and practical test.

One point remains to be considered, and it arises from what I have said early in this article, in bringing out the difference between the coach and the teacher. However good the system is, it will never succeed in producing the desired result unless the agent, in this case the teacher, is competent to develop its potentialities. The aspect requires no enlargement, as its essential nature appears to be fully recognized and formed the subject of much discussion at the Simla Conference. For the present purpose it is sufficient to point out that the supply must be derived from the Agricultural College and forms a third legitimate field, additional to the two already described, of activity for the college.

The proposals outlined above constitute a scheme for providing for the educational needs of the largest section of the community, and, as far as considered, suffices for the main educational function, to fit the average youth for a useful and contented life in the conditions under which he was born. There remains the second aspect, without which no educational system can be considered complete, that of providing a ladder by which those intellectually qualified can arise. If such a ladder is to be provided, it follows that a system of secondary schools leading to the University or to the Agricultural College must be introduced. On this subject the Simla Conference showed considerable diversity of opinion, and the probability is that the exact direction in which this will develop cannot be forecasted with any degree of certainty, and will depend on the exact form of school that is found to succeed. I will content myself with noting a single point. The type of school I have outlined contemplates the performance of the field-work by the pupils, each holding possessing a body of pupil labourers of decreasing age. If such a scheme is to succeed, and the practical work is to be carried out with that efficiency which will alone ensure success, the oldest pupils must have attained a physical development enabling them to do the more arduous field labour. That consideration would seem to indicate that greatest efficiency will be developed in those schools where the age limit is relatively high, and hence that the type is

best adapted to schools of the secondary class. The absence of the necessary physical power in the students of the Loni School was one of the points that struck me most forcibly in the one visit I was privileged to make to that school. It would appear possible that schools of this type would lead directly to the college, and that the ladder we desire would be provided in this manner. The truth is that the practical difficulties, not the least of which is the absence of teachers, are such that the development of such schools must be slow and will afford ample opportunity for gaining practical experience. It is not desirable, therefore, at the present time to enter in too great detail into such matters. It is essentially a case for trial and experiment, the establishment of a few schools of the type described and their gradual extension in that direction which experience shows to be most desirable. What is essential is a clear comprehension of the fundamental principles which underlie the problem—a comprehension so sharp that it can be used as a test during each stage in the experiment. To the best of my ability I have attempted to supply the materials for such a test.

PRESENT POSITION AND FUTURE PROSPECTS OF THE NATURAL INDIGO INDUSTRY.

IV. THE EFFECT OF SUPERPHOSPHATE MANURING ON THE YIELD AND QUALITY OF THE INDIGO PLANT.

BY

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In a preceding article[1] I pointed out that owing to the rapid impoverishment of the Bihar indigo soils during recent years the position of the indigo industry has become very critical. When the Java variety of plant was first introduced into Bihar extraordinarily high yields of indigo were obtained—sometimes as much as 30 to 40 seers of 60 per cent. indigo per acre—but after two or three years the yield of indigo began rapidly to decline. The mysterious disease "wilt" appeared in 1907, characterized by the partial or complete loss of the *khoonties* or second cuttings and failure of seed crops. In my last article I showed that the failure of crops was progressive, becoming more and more marked each year until, in some cases, the yield of indigo was reduced by nearly two-thirds. Not only was there an increasing failure each year of khoonties, but the *moorhan* crop became of inferior quality and yielded less produce. In the years immediately preceding the war, as indigo became a less and less paying crop, the area under indigo was greatly reduced, and this to some extent relieved the situation by giving the soils a chance to recover, but the greatly increased growth of indigo which followed the outbreak of war in 1914 and

[1] *The Agric. Jour. of India*, vol. XIII, page 441. (*Indigo Publication* No. 2.)

its continuous cultivation during the past four years has again created a critical situation.

A year ago, from a detailed study of the indigo soils of Bihar,[1] I concluded that "*unless superphosphate manuring is generally adopted, an enormous falling off in the output of natural indigo will occur during the next few years,*" just at the time when it is essential that produce should be at a maximum in order successfully to compete with the synthetic. This prophecy, I regret to say, has been realized this season at most factories. From reports which have been sent to me of the results of this season's moorhan mahai, *in many cases the produce obtained has only been about one-half that obtained in the corresponding mahai last year. Even where there has been a fair yield of actual green plant per acre, very little dye could be extracted from it.* In several cases the produce per acre has been less than 5 seers of cake indigo from Java plant, which, compared with the yields of 30 to 40 seers which were obtained in the early days of the introduction of this plant in Bihar, is lamentably small. As one planter has put it, "*The produce this year as well as the crop have been the worst on record.*"[2] In my last article I emphasized[3] that in the year 1917-18 the average yield of indigo per acre in Bihar fell off by nearly 20 per cent. as compared with 1916-17; this year, as I feared, the yield per acre will be far less than in 1917-18.

There is no doubt that the climatic conditions this year have been very unusual, and a series of analyses made of the growing plant, which will be published later, shows that the indican content of the leaf has been unusually low. But that the principal factor in determining high yields of indigo (not merely of green plant per acre, but the produce from it) lies in the nature of the available

[1] *Indigo Publication* No. 1, page 66.

[2] In this particular case the actual indigo obtained was of far lower *quality* than that made last year. Whereas last year the indigo made at this factory was very high grade, a large proportion containing more than 70 per cent. of indigotin, seven samples out of the fifteen analysed by me this year contained less than 55 per cent., and only two samples contained more than 60 per cent. It is very significant that *all* the best dates were from Sumatrana indigo and *all* the worst (in these the indigotin was less than 50 per cent.) were from Java indigo.

[3] *The Agricultural Journal of India*, vol. XIII, pt. II, page 451. (*Indigo Publication* No. 2, page 10.)

foodstuff *in the soil* at the time the plant is grown appears clear from the results which will now be recorded.

THE EFFECT OF SUPERPHOSPHATE MANURING ON THE YIELD OF INDIGO PLANT PER ACRE AND ITS RICHNESS IN INDICAN.

During the past season only a very few planters made trials with superphosphate manuring on their estates. But where such experiments were made the results were very favourable and fully confirm the view I have so frequently expressed that the depletion of available phosphate in the soil has been the principal cause of the failure of indigo crops in Bihar of recent years, and that by proper manuring it will be possible again to obtain the high yields of indigo which were given by the Java plant when first introduced into Bihar. The following cases may be quoted:—

(1) Mr. L. W. Lydiard of Nawada, Champaran, reported on 6th June, 1918:—

"I sowed 4 acres of Java in lines for a seed crop in the first week of August (1917) and put in super a week before sowing. I got about 4 maunds an acre of seed* and cut the crop down at the end of March and have now *splendid* khoonties in the 4 acres, which I shall be cutting next week, 3 feet high. I also 'supered' 5 acres of general crop Java, putting down the super at 2 maunds an acre, middle of September; sowed *gram* and Java ten days later and got a very heavy Hatthia rain on it. Thirteen acres were sown at the same time (that is 8 acres without super, 5 with). **The gram crop was good in the five acres with super and a failure in the eight acres. The indigo is magnificent in the five acres and wretched in the eight acres.** The lands are of one and the same sort and last year *all of it gave a poor crop*. I am getting three or four times the quantity of super this year. If only

* This is an unusually good yield at the present time. Most estates yield no seed at all or only about 1 maund per acre.

super were available at pre-war rates, I should put it in all my *zerat* lands."

(2) Mr. A. W. Fremantle reported on 12th July, 1918:—

"I tried superphosphate to a small extent last season—*the one acre (with super) gave 12 carts per acre moorhan as compared with the acre next to it which gave 6.* The rest is in *makai* (maize) and *bhadai dhan* (rice) land and the increase remains to be seen."

(3) Mr. E. Moore of Barah, Champaran, reported, on 9th April, 1918, the results obtained by growing Java indigo for seed, in one case with superphosphate only, in the other with cow-dung as manure. The details are as follows:—

(*a*) *With super*: Barra Dih Zerat. Two bighas. Super applied 1½ maunds per bigha, July 19th, 1917. Indigo sown August 6th. Total yield of indigo seed = 6 maunds 35 seers, that is *3 maunds 17½ seers per bigha.* The plant was only slightly diseased and grew to the height of about 4 feet.

(*b*) *With cow-dung only*: Mohowahwara Zerat. Eight bighas. Manured with cow-dung, and indigo sown for seed crop on 18th July. Total yield of seed from the 8 bighas = 6 maunds 15 seers (*that is only 32 seers per bigha*). The plant was badly diseased and about 3 feet high.

It is clear from these results that manuring with cow-dung alone is not sufficient to ensure a good crop of indigo seed under present conditions of the soil.

(4) Mr. F. B. Robinson of Sagrampur, Bhagalpur, writes (23rd August, 1918): "I experimented with this manure (superphosphate) this year and with lime, having 12 plots each of $\frac{1}{10}$th acre. *The plots (two in number) which had super in them were the only ones that yielded any sort of crop of indigo.*" In a later letter Mr. Robinson writes (15th September): "The effect of superphosphate was wonderful, and I shall manure several acres this year." Mr. Robinson gives the following summary of

the results obtained on the small experimental plots (each $\frac{1}{10}$th acre in area).

Manure on plot	Produce	REMARKS
$5\frac{1}{2}$ seers super	$5\frac{1}{4}$ bundles plant	Plant 3 feet high and very leafy
5 seers super	5 ,, ,,	Ditto
17 mds. lime per bigha	1 bundle ,,	About 1 foot high, hardly any leaf
$8\frac{1}{2}$ mds. lime per bigha	1 ,, ,,	Ditto
No manure	1 ,, ,,	Ditto

The analyses of the Sagrampur soils are given in *Indigo Publication* No. 1. They differ very strikingly from most of the Tirhut soils in being very deficient in lime as well as in phosphate. Manuring with superphosphate at the rate of $1\frac{1}{4}$ mds. per acre increased the yield of indigo five-fold, whereas the addition of lime alone gave no increase of crop.

(5) The most striking results with indigo, however, were obtained by Mr. G. Moore of Moniara, Saran.* On June 5, Mr. Moore reported :—" As regards superphosphate, after green-manuring with *sannai* I applied super and I am pleased to tell you the lands treated *thus have a splendid crop of Java and it was poor land. I also kept* a *chakla fallow, of good quality* : *the Java on this is not so good as the other.*"

* Mr. H. L. Russell of Suddowah, Saran, has reported the effect of superphosphate on oats during the past season (5th June, 1918) : " Just a line to tell you that on the few bighas of oats where I put down superphosphate my outturn was $7\frac{1}{2}$ maunds per bigha. My total outturn on the rest of the lands was $4\frac{3}{4}$ maunds the bigha." It should be noted that owing to the failure of rains in the cold weather of 1917-18, the yield of oats throughout Bihar has been exceptionally poor. Colonel V. N. Hickley (3rd May, 1918) has sent me the following details with regard to the effect of super-manuring on the oat crop at Ottur.

			Average return of oats per bigha	
			Maunds	Seers
Season 1915-1916	..	No seet but 2 maunds super per bigha	12	21
,, 1916-1917	..	,, ,, ,,	11	3
,, 1917-1918	..	No super, no seet	5	1

As already stated the oat crop was poor in Bihar this year owing to lack of winter rains, and Colonel Hickley states that " in a normal season the outturn without super should have been 8 maunds per bigha."

At my request Mr. Moore made arrangements separately to mahai the indigo grown on the land manured with super and sannai, so as to compare the produce obtained from such plant with that grown on the same estate and at the same time under other conditions of treatment. On July 17, Mr. Moore sent me the results given in Table I (pp. 40-41). On this date he reported :—"I had very fine Java plant this year, but the *best crop was on the land green-manured and treated with super afterwards—not very high, between 5 and 6 feet, but covered with leaf.*" On August 23, he wrote :—"Khoonties I am sorry to say were a wash-out this year. *What there are though are on the super-treated lands which is satisfactory.*" Mr. Moore's results are particularly valuable in showing the enormous effect of proper manurial treatment on the *quality* of the indigo plant—that is, its richness in indican and the "produce" it yields. As this side of the question has hitherto been largely overlooked, although of supreme importance, it is desirable here to consider the results in some detail from this point of view.

THE EFFECT OF MANURIAL TREATMENT ON THE QUALITY OF THE INDIGO PLANT.

The following Table (II) abstracted from the data in Table I shows the yield of green plant per acre, the weight of cake indigo obtained per acre, the yield of cake indigo per 100 maunds of green plant, and the weight of green plant required to produce one maund of cake indigo under different conditions of manurial treatment.

TABLE II.

Yields of indigo from Java plant at Moniara under different manurial conditions.

Date of mahai	Treatment of land	Acres cut	Average yield of plant per acre		Average yield of cake indigo per acre		Quality of plant: Yield of cake indigo per 100 mds. plant		Quality of plant: Green plant required to produce 1 md. indigo		Remarks
			Mds.	Srs.	Srs.	Ch.	Srs.	Ch.	Mds.	Srs.	
June 17 ...	... Kept fallow 12 months ...	10·47	95	12	10	5	10	14	368	0	This land was of better quality than that treated with super and sannai
" 18 ...	... Super and sannai	9·60	94	6	13	2	**13**	**15**	**284**	**20**	Steeping with very cold water (83°F.)
" 19 ...	... Jamoona Singh's *khuski* ...	2·41	208	20	16	12	8	0	497	15	Java grew to tremendous height in these two fields—8 feet—but more wood than leaf
" 22 ...	... Manured with seet water ...	3·05	218	28	14	12	6	11	593	0	
July 4 ...	... Super and sannai	4·01	**153**	**1**	**32**	**4**	**21**	**1**	**189**	**20**	Height of crop 5 to 6 feet. Covered with leaf from top to bottom
" 5 ...	... Seet dug in with *kodali* ...	8·29	79	34	12	10	15	13	252	10	
" 6 ...	... Seeted land sown in February, along with Sumatrana	7·85	119	32	16	15	14	2	282	10	
" 7 ..	... Seet dug in with *kodali* ...	13·09	84	11	11	7	13	10	233	0	
" 8 ...	... Java of Bhoji Chaper mixed with February sowing	10·04	88	23	13	3	14	15	267	10	
" 9 ...	... February sowing of Java ...	13·83	72	24	6	5	8	11	458	20	
" 10 ...	... February sowing and Hiranda plant	12·22	78	4	11	2	14	4	279	20	

The following points stand out very clearly as regards the effect of conditions of growth on the *quality* and yield of produce :—

(*a*) In the early June cuttings, a fortnight after the break of the rains, the *quality* of the plant grown on super and sannai was far higher than that grown under other conditions, as shown by the highest yield of cake indigo per 100 maunds of plant* (*viz.*, 13 seers 15 chataks). But at this stage the plant grown on super and sannai was not fully developed and the yield of green plant per acre was lowest (94 maunds per acre). There was an enormous growth of plant on the *khuski* land and on the land manured with seet-water, but although the plant was very tall it was of poor quality and contained little leaf.† The consequence is that the yield of cake indigo per 100 maunds of plant was very small (8 seers 0 chatak and 6 seers 11 chataks in these two cases). On the land manured with seet-water there was a rapid *forced* growth of indigo, and the plant grew to a great height (8 feet), but there was very little indigo in the plant. The consequence was that it took 593 maunds of green plant to produce 1 maund of indigo as against 284 maunds of the *rich* plant grown on super and sannai.

The plant grown on super and sannai was very much better in *quality* than plant grown on *better* land which had not been treated with manure, but left fallow for 12 months—as shown by the yield per 100 maunds of plant being 13 seers 15 chataks as against 10 seers 14 chataks. Thus although the actual yield of *plant* per acre was slightly less (94 maunds 6 chataks as

* On the day this plant was worked the conditions were, too, most unfavourable for a good steeping, the water being exceptionally cold (83°F. instead of the customary 90°F.).

† The growth on these lands was forced by the high proportion of nitrogenous food in the soil. It grew to a great height (8 ft.) but the lower leaf was rapidly shed in consequence of unbalanced growth. As a result the plant in June largely consisted of stick and it gave a very poor yield of indigo. On the other hand, the plant grown on super and sannai although fairly tall was covered with leaf from top to bottom.

against 95 maunds 12 chataks), the actual produce of indigo *per acre* was considerably higher (13 seers 2 chataks as against 10 seers 5 chataks).

On June 18th, however, the plant grown on super had clearly not reached maturity and was not really ready for cutting. This is shown by the greatly increased yields obtained when the same plant was cut a fortnight later (July 4). Consequently at the earlier stage (June 18) the yield *per acre* (13 seers 2 chataks) was somewhat less than in the case of the khuski crop and the land manured with seet-water (yields 16 seers 12 chataks and 14 seers 12 chataks per acre, respectively) where there was an enormous, *rapidly grown crop* of poor quality.

(*b*) In the interval between June 18th and July 4th, there was heavy rain (15 inches) followed by a dry spell between June 27th and July 4th. In this period the plant grown on super and sannai developed considerably—the yield *per acre* increased about 60 per cent. (from 94 maunds 6 seers to 153 maunds 1 seer), whilst the *quality*, judged by the yield of indigo per 100 maunds of plant, was increased also to the same extent (from 13 seers 15 chataks per 100 maunds of plant to 21 seers 1 chatak). By the first week of July not only **was the actual yield of green plant per acre far higher in the case of the super-treated land, but the quality was also far superior, so that the yield of cake indigo per acre reached the phenomenal value of 32 seers 4 chataks per acre for a single cutting.**

This value is from 2 to 3 times that obtained from plant grown on the seeted land and mahaied at practically the same time (July 5th, July 6th and July 7th).

(*c*) The figures given for the average yield of cake indigo per acre *dispose of the view frequently taken by planters that the low yields of indigo recently obtained on most estates are due to deterioration of the Java indigo plant.* It is clear

that when the soil conditions are favourable (and these favourable conditions can, I consider, be largely assured by proper manuring) enormous yields of indigo can be obtained even in a year of unfavourable climatic conditions and with the existing Java plant. The yields per acre of 153 maunds of green plant and 32 seers of cake indigo for a single (moorhan) cutting far exceed the yields obtained from the Java plant in its palmiest days—shortly after its introduction into Bihar. Thus in the case of the extraordinary yield of 41½ seers of cake indigo per acre obtained at Bhagwanpur[1] in 1906-1907, this was made up of *three* cuttings, which gave respectively 14 seers 9 chataks, 17 seers 4½ chataks, and 9 seers 12 chataks. Such a yield as 32 seers of cake indigo from a single moorhan cutting is, I believe, almost without precedent. The actual yield obtained at Moniara on land treated with super and sannai far exceeded my most sanguine expectations of what could be accomplished in a single season by proper manurial treatment. It cannot of course be expected that *all* lands will respond at once in the same marked way to manurial treatment, but it appears to me certain that the majority of lands in Bihar can, by steady manuring for a few years, be made to yield 20 to 30 seers of indigo per acre *in the course of the two mahais.* This result will be attained not merely by increasing the yield of green plant per acre, but largely by improving its quality, that is by allowing the plant to grow under conditions which bring about a maximum content of indican in the leaf.

It is not sufficient merely to obtain a rapid and abundant growth of green plant. Such a growth may be obtained by manuring with seet or seet-water, or other

[1] *The Agricultural Journal of India*, vol. XIII, pt. III, p. 446. (*Indigo Publication* No. 2, p. 6.)

nitrogenous manures, such as cattle manure or oilcake. But the general experience of planters is that plant grown under such conditions has "nothing in it," and fails to yield good produce. This view is confirmed by the results in Table II obtained on June 19th and 22nd, where there was a phenomenally large growth of plant in two fields (208 and 218 maunds per acre for the first cutting) but the produce per 100 maunds of plant was very low (8 seers and 6 seers respectively).*

From the results at Moniara it would appear that a combination of green-manuring with sannai and superphosphate is an ideal one to ensure not only a high yield of plant, but also high quality. Whether this is so in general can only be decided by actual trials on the large scale. Unfortunately at Moniara no trials were made for comparison with superphosphate alone. There is the danger that abundant green-manuring with sannai may encourage rapid and forced growth of plant at the expense of quality. That this was *not* the case at Moniara, and that the nitrogenous constituents of the sannai only came slowly into action without forcing growth, is shown by the fact that on June 18th the yield of green plant per acre (94 maunds 6 seers) was only the same as on the fallow land (95 maunds 12 seers), whereas on the seeted and khuski land the yield of green plant at the same date was double as great (218 and 208 maunds respectively). But in the fortnight from June 18th to July 4th, the plant grown on the land treated with super and sannai, grew rapidly and also improved enormously in *quality*. The final plant obtained, however, was never so tall as on the seeted lands in

* Compare also Rawson's data (Report, page 13)—By manuring with seet (5 tons per acre) the yield of plant *per acre* was nearly doubled, but the produce per 100 maunds of plant halved, so that the yield of dye remained practically the same as on unmanured land.

June—it only reached a height of 5 to 6 feet as compared with 8 feet on the seeted lands—but *it was covered with leaf from top to bottom, and the leaf was obviously very rich in indican.*

(*d*) Some planters seem inclined to attribute the abnormally low produce obtained this season—a result which last year I foretold would occur—to abnormal climatic conditions, rather than to the real cause, which I consider is the exhaustion of the soil of its available phosphate supply. That the climatic conditions have been abnormal is very true—a very early break of the monsoon (June 1st) followed by an interval of 10 days without rain, then a heavy downpour on June 23rd and 24th again followed by a 10 days' break. Between July 5th and 11th, 8·39 inches fell at Pusa, and then there was another prolonged break from the 16th to 26th with heavy showers from July 27th to August 1st. From August 2nd to 5th no rain fell, but the 6 days from August 6th to August 11th were very wet with 14·00 inches of rain.

But the fact that even in this abnormal season,* on the land manured with super and sannai at Moniara, such

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* There was practically no winter rainfall in 1917-18. At Pusa up to June 1st, the rainfall was 4·47″.

From June 1st to June 5th	2·48″
,, ,, 6th to ,, 8th	2·90″
,, ,, 9th to ,, 11th	0·70″
,, ,, 12th to ,, 22nd	0·74″
(A break of 10 days in which only slight showers occurred on 8 days.)	
From June 23rd to June 24th	4·61″
,, ,, 25th to July 4th (break of 10 days)	0·07″
,, July 5th to July 7th	0·84″
On ,, 8th	5·16″
From ,, 9th to 11th	2·39″
On ,, 12th	0·00″
From ,, 13th to 15th	1·52″
,, ,, 16th to 26th	0·03″ (Ten days' break.)
On ,, 27th	0·76″
,, ,, 28th	0·00″
From 29th July to 1st August	1·01″
,, August 2nd to August 5th	0·00″
,, ,, 6th to ,, 11th	14·00″

an extraordinary yield of indigo as 32 seers per acre could be obtained *in a single cutting* even with the present Java plant shows that the *principal* factor is apparently the *soil conditions*.

Manuring with sannai and superphosphate produced not only the maximum yield of green plant per acre, of all the Java indigo cut between July 4th and 10th, but also by far the *best quality plant*. The *quality* is clearly as important as, if not more important than, the *quantity*. The writer has in progress, in collaboration with the Imperial Agricultural Bacteriologist and Imperial Agriculturist, a number of experiments which are designed to throw light on the best methods of growing indigo to ensure not only a maximum yield of plant, but a maximum indican content. The plant is being grown under different conditions of manuring, and the changes in quality followed by analyses of the leaf and the proportion of leaf on the plant from time to time. When the plant is cut it is possible to calculate the actual potential yield of indigo from the proportion of indican in the leaf and the actual yield of green plant per acre. The results of this season's trials will be published in detail later.

The reasons for the rapid impoverishment of indigo soils during the past 20 years.

Many planters find it difficult to understand why soils, which grew indigo successfully for 100 years continuously, apparently suddenly, during the last 20 years, have shown marked signs of deterioration. It is not, I think, generally realized that after 1897, the year when synthetic indigo first began seriously to compete with indigo, a complete revolution took place in the methods of indigo cultivation in Bihar. The following sketch based on information kindly imparted to me by Bernard Coventry, Esq., C.I.E., will indicate the general nature of the changes which have occurred and have been responsible for a far more rapid exhaustion, in twenty

years, of the indigo soils than occurred under the old system of working in a century.

Under the old system, up to 1897, the planter took in farm (*thikadarry*) whole estates from Indian landlords usually on a 9 years' lease, very frequently paying down in cash the whole of the 9 years' rental called *zurpaisky* or *surzamanath.* He took into indigo such lands as the landlord had in his own possession, and he contracted with the tenants for from one-seventh to one-tenth of his holding to be sown in indigo. This contract was either on the *asamiwar* system as in Champaran, where the tenant kept possession of his land and grew the crop, or on the *dehai* system as in the districts of Muzaffarpur, Darbhanga and Saran, where the contract was for the planter to prepare the lands and grow the crop himself. It is to be observed that under this system villages or estates were *constantly coming in or going out of lease* and large sums of money were yearly being expended in the shape of rent-in-advance (*zurpaiskies*) paid to the landlord for these leases. *This constant renewal was made easy by the unlimited financial facilities afforded at that time by the Calcutta Agency Houses*; indigo being then a flourishing monopoly industry their money was absolutely safe. When the lease of a village expired it did not necessarily go out of indigo cultivation: frequently the lease was renewed as before and the rent-in-advance paid down in cash. But there was always each year a number of cases where the renewal was not made and the lands went out of indigo only to come back under a fresh lease a few years later. In those days, there was also a certain number of quite new villages coming into fresh lease every year. The two important features to be observed in this system are, first, that the planter was financed to any limit by the Agency Houses which enabled him to treat for the lease of villages or estates with ease and on profitable terms, and, secondly, that *the large number of first leases and of leases renewed some years after the villages had been returned to the landlords, contributed towards keeping up the indigo-producing power of the lands.*

But, further, it was the custom to exchange indigo lands for cultivators' lands on a very considerable scale. Every year the

assistant would go round the cultivation before mahai when the indigo crop was in the ground, and indigo lands which showed the appearance of being worn out he would there and then measure. He would then, in agreement with the cultivators, measure an equal area of their lands and the exchange would be made for the next crop. This exchange was to mutual advantage and was recognized to be so by the cultivator who knew that indigo lands gave him a heavy crop of wheat, etc.

The total area thus affected by the leasing of villages and the *budli* or exchange mentioned would roughly approximate to one-fourth to one-third of the cultivation per annum at Dalsing Sarai. These favourable aspects do not now exist in their entirety. When synthetic indigo began seriously to compete with natural indigo, the Agency Houses tightened their purse-strings, not only in respect of money required for advance rent for leases, but also in respect of ordinary current expenditure. *This deprived the planter of the command he formerly had on the acquisition of fresh land for growing the crop, and it also compelled him to change his methods of cultivation.* He was now obliged to grow country crops (which he had never done before for profit-earning) on a portion of the lands on which he formerly grew indigo. He did this principally for two reasons—in order to establish a system of rotation to replace the means he formerly had of the easy renewal of leases which had now been taken from him, and in order to find money for current expenditure for such portion of the lands as remained in indigo. This arrangement, however, had not beneficial effects equal to the advantages of the old system, nor did it compensate for these. This will be clear from the following considerations.

Under the new system of cultivation imposed by the changes referred to, the planter restricted his area under indigo and introduced country crops. He did not, however, generally speaking, grow the country crops himself, but gave out to tenants the lands, usually manured with seet, on which they grew the crops. The tenants gave the planter either rent or a share of the produce which yielded a greater profit than indigo so far as these particular manured lands were concerned. He also let out into country crops some of

the lands for which there was no seet available, naturally on less favourable terms.

It must be observed that the first effect of this system was to lessen the amount of seet owing to the restricted area under indigo, so that although at first, when there was a plentiful supply of seet, this method promised well, it has gradually led to disappointment, because the area which can now be treated is often so small that the average profit earned on the whole area under country crops is exceedingly small, and sometimes even represents a loss. With the increasing failure of the indigo crop and the lack of seet as a manure which this entails, the present system promises disaster in the next few years. The system has moreover other imperfections. The lands are usually given out to cultivators for three or four years. The aim of the cultivator is to "milk" the land so as to make all the money he can out of it and return it to the planter in an exhausted state. Further, the seet which is given to him aids in the process, for being a manure with an excessive amount of nitrogen, it tends to draw unevenly on the available supplies of phosphoric acid already in defect, and makes the deficiency worse.[1] When introducing this system the planter abandoned the old custom of budli because he grew indigo only in lands which were expected to give a full crop—though in this he has been disappointed also, owing to the development of the so-called "wilt." He finds too that wilt now prevails in lands taken in budli.

I would also emphasize the fact that the "series" of crops grown has not in most cases been a true rotation at all. In a proper rotation the selection of crops is such that the fertility of the land is maintained by establishing a balance between the constituents removed by the crops and those liberated by the ordinary soil changes in successive years. The leguminous crop which always forms part of a proper rotation renovates the soil by replacing nitrogen. But in the case of the planters' lands the crops grown have simply continuously *stripped* the soil of the constituent which they especially lack—available phosphoric acid. Thus to take an

[1] *Indigo Publication* No. 1, pages 36-38.

actual example of a field which was formerly let out to ryots for cultivation, the series of crops was :—

1913	Winter crop, tobacco.
1914	Maize followed by winter crop of wheat.
1915	Maize with *rahar* as *rabi* crop.
1916	Maize followed in October with indigo and mustard together.

It was not surprising to find after this continuous stripping for several years (the earlier record whilst the land was in the ryot's hands is not known) without any application of manure, save one dressing of cattle manure in 1913, that this particular soil when analysed in 1917 contained only 0·037 per cent. of total phosphoric acid and 0·0006 per cent. *available*, even in the top 6″. On many other fields on the same estate the *total* phosphoric acid in the top layer exceeded 0·1 per cent., whilst the *available* was 0·001 to 0·002 per cent. in the *surface* layer. It was also not surprising to find that the indigo and mustard sown in 1916 did not thrive—the mustard dying out completely some time after germination and the indigo following suit.

In the old days, when indigo was grown as the sole crop, the land was ploughed several times and fallowed for a long period. There was no crop in the land from September up to the following February, when the old Sumatrana indigo was sown, during which period—the dry weather—there was ample opportunity for bacterial action in the soil to liberate a fair supply of mineral plant food. Only the one crop—indigo—was grown in the year. Under the present system *two* crops are frequently taken out in the year, when indigo is not grown, and these are often very exhausting crops—such as tobacco. When Java indigo is sown in October, it frequently immediately follows another crop, either of indigo or some cereal such as maize, without the soil having a chance properly to recover. With Java indigo, which remains on the land for nearly a whole year (October to September), two or more cuttings are taken which is equivalent to growing two ordinary crops.

To sum up: The changes imposed on the cultivation in Bihar by the appearance of synthetic indigo in 1897 have, during the past 20 years, greatly altered the general character of the soil and necessitated a fresh method of treatment. Planters have been deprived

of the financial aid which was formerly available to enable them to take leases of large parcels of land in which exchange was easily assured, either by the taking of first leases, the renewal of old leases after the lapse of some years, or by the budli or exchange of indigo lands with cultivators' lands. In place of these advantages they have had to ring the changes on the same land under a system leading to certain, and in many cases rapid, exhaustion. When lands have been let out to ryots, it has been to grow exhausting crops such as tobacco and chillies, and the soil returns to the planter in a very impoverished condition.

There are of course notable exceptions to the conditions depicted above. Thus planters frequently point out to me that certain fields have given good crops of indigo continuously year after year for an unlimited period. These fields are usually the sites of old villages and are of high fertility, mainly owing to the accumulation of human and animal excreta for generations. In these the process of exhaustion will naturally take far longer before they show a failure of crops. But such cases are the exception, not the rule.

Again, many planters have expressed to me their difficulty of understanding how soils which gave good indigo crops for a hundred years should quite suddenly show a rapid falling off such as followed the appearance of wilt in 1907. Actually this is the very behaviour which was to be expected. It is quite easy to understand that if a soil originally contains 100 parts of "available" phosphate and the crop removes one part each year, no marked falling off of crop will occur for 98 to 99 years, but that then quite suddenly the crop will fail to an increasing extent each year because it can no longer easily obtain the one part of phosphate corresponding with a full crop. It must be clearly understood that a *certain* amount of regeneration takes place each year in the soil owing to the liberation of *water-soluble phosphate* by the ordinary soil agencies (bacterial action, following cultivation or fallowing) acting on the insoluble mineral phosphates (in the analyses termed "total phosphate") always present in the soil. But the trouble at the present time is that the amount of this regeneration each season is not sufficient to give a full or even a good crop in the case of indigo. Moreover, this

regeneration takes place only in the *surface* layer of the soil where the soil agencies are most active. The soluble phosphate produced is rapidly used up by surface growing crops, and there is no opportunity for the small amount of soluble phosphate liberated to wash down into the lower layers of soil (where the Java plant mainly feeds) to renovate them. The consequence is that soils are frequently found which still give good or fair results with oats, barley or country crops, but fail more or less completely with indigo. One of the most striking instances of this kind may be cited—Byreah, Field No. 1* where the following analyses were obtained :—

Depth	Total P_2O_5	Available P_2O_5
0—6″	0·1371	0·00505
6″—12″	0·1273	0·00136
12″—36″	0·1049	0·00020

Here the amount of available phosphate in the *surface* layer is relatively very high for Bihar—not far short of the quantity generally regarded as necessary for good fertility in Europe (0·01 per cent.). But below 12″ the amount of available phosphate is extremely small (0·0002 per cent.). The behaviour of indigo grown in this land exactly corresponded with what would be expected from the analysis. The plant grew very well for 2 or 3 months, but when it reached a height of about one foot, growth was checked and large patches died out. The deep feeding roots of the Java indigo had reached a layer of soil in which there was no longer proper nutrition.

The complete revolution in the system of cultivation in Bihar, which followed the capture of the indigo market in 1897 by the synthetic dye, led to a far more drastic stripping of the soil. Under this new system the soils are now showing signs of rapid deterioration. If crops are to be maintained in the future, the method which has been adopted in all civilized countries—scientific manuring—must be introduced. Some 20 to 25 planters have expressed their willingness to make trials on their estates with superphosphate this season. The principal difficulty has been to obtain superphosphate, but it is hoped that in several cases at least supplies will be at hand before the rains cease, so that the effect can be seen on next year's crop.

* For full particulars and analyses see *Indigo Publication* No. 1, page 52.

TABLE

Statement of produce from Java plant at various stages

Date	Particulars	Bighas cut	Acres cut	Green plant	Average plant per bigha	Indigo made per press of 20 srs.	AVERAGE per bigha	AVERAGE per acre
1918		B. C.		M. S.	M. S.	M. S.	S. C.	S. C.
June 17 ...	Kept fallow 12 months ([1])	12 0	10·47	998 0	83 20	2 20	8 5	9 8
„ 18 ...	Superphosphate and sannai ([2])	11 0	9·60	903 30	82 6	3 0	10 14	12 8
„ 19 ...	Jamoona Singh's *khuski* ([3])	2 15	2·40	500 20	182 0	1 0	14 8	16 10
„ 22 ...	Manured with seet-water ([4])	3 10	3·05	667 10	190 20	1 3	12 4	14 1
July 4 ...	Superphosphate and sannai ([5])	4 12	4·01	614 0	133 20	3 0	26 1	29 14
„ 5 ..	Seet dug in with *kodali*	9 10	8·29	662 0	69 20	2 20	10 8	12 1
„ 6 ...	Seeted land, sown in February along with Sumatrana ([6])	9 0	7·85	938 30	104 10	3 0	13 5	15 4
„ 7 ...	Seet dug in with *kodali*	15 0	13·09	1,103 0	73 20	3 20	9 5	10 11
„ 8 ...	Java of Bhoji Chaper mixed with February sowing	11 10	10·04	889 10	77 10	3 0	10 7	11 15
„ 9 ...	February sowing near Amla's Derakarsingh Tewary Toke	15 17	13·83	1,004 30	65 6	2 0	5 0	5 12
„ 10 ..	February sowing and Hiranda plant	14 0	12·22	954 20	68 7	3 0	8 9	9 13
	TOTAL ...	108 14	94·85	9,235 30	85 0	27 23	10 3	11 10

([1]) This land is of better quality than
([2]) Note the coldness of the water. The
([3]) Java in this field grew to a tremendous
([4]) Java in this field grew to a tremendous
([5]) Height of crop 5 to 6 feet, *covered with*
([6]) This Java was put down at the same

N.B.—There is a very big difference in the produce from 18th June to 4th July from the same sun from 27th June to 4th July.

I.

of mahai and from various qualities of land at Moniara Concern.

PRODUCE per 1,000 c.ft. of vat		per 100 mds. green plant		Green plant per one maund indigo		Indigo made by cake measurement at 7 srs. per inch		AVERAGE PRODUCE per bigha		AVERAGE PRODUCE per acre		AVERAGE PRODUCE per 1,000 c.ft. of vat		AVERAGE PRODUCE per 100 mds. green plant		AVERAGE PRODUCE Green plant per one maund indigo		Temperature of water in khajana. °F.
S.	C.	S.	C.	M.	S.	M.	S.	S.	C.	S.	C.	S.	C.	S.	C.	M.	S.	
13	14	10	0	399	0	2	28½	9	0	10	5	15	1	10	14	368	0	86
16	10	13	4	301	10	3	6	11	7	13	2	17	8	13	15	284	20	83
11	1	8	0	500	20	1	0¼	14	10	16	12	11	3	8	0	497	15	88
8	5	6	8	612	0	1	5	12	13	14	12	9	6	6	11	593	6	86
25	0	19	8	203	20	3	9½	28	2	32	4	26	15	21	1	189	20	90
20	13	15	1	264	30	2	25	11	0	12	10	21	14	15	13	252	10	88
16	10	11	8	346	30	3	13	14	12	16	15	18	7	14	2	282	10	88
19	7	12	11	315	0	3	30½	10	0	11	7	20	14	13	10	293	0	88
16	10	13	7	296	10	3	13	11	9	13	3	18	7	14	15	267	10	88
11	2	7	15	502	10	2	7½	5		6	5	12	1	8	11	458	20	88
16	10	12	9	318	0	3	16½	9	12	11	2	19	0	14	4	279	20	89
16	2	11	15	334	30	29	34¾	10	15	12	9	17	7	12	14	309	0	...

that treated with sannai and super.
day was also very cloudy and cold.
height, 8′ at the least and more wood than leaf.
height, 8′ at the least and more wood than leaf.
leaf from top to bottom.
time as Sumatrana, February and March.
field. This is attributable to very heavy rain in June, 15·60″, and there being a dry spell of hot

SOME OF THE PROBLEMS ARISING OUT OF THE SUCCESSFUL INTRODUCTION OF AMERICAN COTTON IN THE WESTERN PUNJAB.*

BY

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THE introduction of American cotton in the Punjab by the Agricultural Department has brought out a number of problems, partly owing to the difficulties experienced by the Department in this work, and also on account of the success which has attended the work. In order to appreciate these difficulties it is necessary briefly to outline the outstanding features of the work. Work on American cotton started at Hissar in 1902 and at Lyallpur in 1903 and 1904. Previous to that there were some plants of American cotton to be found among the *desi* or country cotton grown, especially in Shahpur, Lahore and Jullundur. The very severe bollworm attack of 1905 and the somewhat less severe attack in 1911 were found to affect American cotton to a very much less extent than country cotton. The experience of 1905, and especially of 1911, had a very marked effect on the attitude with which zemindars regarded American cotton. The policy of the Agricultural Department up to 1912 was to import seed from Dharwar every year though most of the zemindars growing this cotton kept their own seed. Experience in 1913 showed clearly that the sowing of seed acclimatized in the Punjab and plants of the rough-leaved type was the only safe policy to adopt. It had appeared for some years that imported seed was not very reliable as it contained so many different types. The Department in 1912 and 1913 put out two special

* A paper read at the Fifth Indian Science Congress, Lahore, 1918.

selections which had been handed over by the Economic Botanist in 1910 for trial at the Lyallpur farm. One of these, *viz.*, 4 F, proved to be a very safe plant and the area under it since 1913 is roughly as follows :—

1913 ...	...	...	...	100 acres.	
1914 ...	...	..	...	4,000 „	
1915 ...	...	. .	...	10,000 „	
1916 ...	...	...	...	30,000 „	
1917 ..	...	...	...	120,000 „	probably 140,000 acres.

The total areal under American cotton in 1917 was 274,000 acres, of which, as will be seen, over half was pure 4 F, and probably another quarter was impure 4 F from mixed seed obtained from ginning factories. The total area under American in 1911 was probably under 10,000 acres and reached 30,000 acres in 1913. It will be seen that since 1911 the increase has been rapid and phenomenal. The reason for the comparatively slow progress from 1903 to 1911 was mainly connected, in the first place, with the fact that the plant was not acclimatized, and, secondly, with the fact that the premium over *desi* cotton was at first only R. 1 to R. 1-6 per maund even in cotton sales and generally only a few annas per maund in the *mandi* or market. Previous to 1908 the cotton used to be sold by arrangement through the Agricultural Department at a premium of R. 1 to R. 1-8, but, owing to delays in recovering money and other difficulties connected with a monopoly, Mr. Milligan, who was then in charge of the work, started auction sales. The quantities at the latter were generally from 300 to 500 maunds and premiums up to R. 1-8 per maund were realized. Sales were temporarily dropped in 1911 and 1912, but were started again in 1913 by the writer both with a view to obtaining the seed of 4 F and to stimulate competition. By 1913 this cotton was becoming known in Bombay, and it was easy to get R. 1 to R. 1-4 premium in the ordinary market. At the sales the premium went up to Rs. 2-8 and Rs. 2-12. Since then the number of sales have increased rapidly until this year the Department will have sold in this way at fourteen sales over 100,000 maunds

[1] *The Agricultural Journal of India*, vol. X. pt. IV, 1915; vol. XI, pt. III, 1916; vol. XII, pt. III, 1917; vol. XIII, pt. I, 1918.

valued at roughly £130,000. Since 1914 all the cotton (*kapas*) coming to the sales is classified according to purity, and no American cotton with over 5 per cent. *desi* cotton admixture is sold at the auctions. Premiums averaging Rs. 4 per maund were obtained in 1916, and the highest price reached this year has been Rs. 21-15 per maund, when country cotton was selling at Rs. 15 per maund. Although the cotton sold through the Department sales is only about 10 per cent. of the whole, the value of these sales has been enormous both in attracting new buyers and in securing a wide and open market. This year four buying agencies representing Bombay and Ahmedabad mills have come forward as active buyers. Since 1915 Messrs. Tata & Sons, who were the first to come into the market from Bombay, have facilitated our task and helped to establish the market. Ordinary Punjab cotton which used to be grown exclusively in the Colonies is classified in Bombay as Sind-Punjab and fetches the lowest price in the market. Punjab-American is quoted since 1915-1916 at from Rs. 20 to Rs. 40 per candy (784 lb.) over Broach, or Rs. 100 to Rs. 150 or more above Punjab *desi*. This means Rs. 4 or Rs. 5 per maund of *kapas*, which is the premium this cotton is fetching at present. One of the conspicuous features with reference to the introduction of a new cotton in India is the slowness with which the trade responds to any change that takes place. This holds true for both superior and inferior varieties and consequently tends to put a premium on work with low grade high yielding cottons such as "Aligarh white" in the United Provinces and "Roseum" in the Central Provinces.

The difficulties encountered have been therefore as follows :—

(*a*) From 1903 to 1911 the problem was to get a fair premium. The cotton began to command premiums independently of sales in 1911, but this premium was far too low and generally only As. 8 to As. 12 instead of Rs. 2 or Rs. 3.

(*b*) With resumption of sales in 1913 premiums went up. The quantity had increased from 10,000 acres in 1911 to 30,000 in 1913. Since 1911 there has been no looking back.

(*c*) In spite of increase in area it was only by bringing in and encouraging outside bidders, *e.g.*, Tatas and Bombay and Ahmedabad mills that fair prices could be obtained. This was largely owing to the combination of the local ginning factories who in the Punjab buy cotton, and these resented the organization of the zemindars by the Agricultural Department and in many cases combined to wreck the sales. Attempts to eliminate abuses in "weighments," "arbitration," and "rejections" met with strong opposition, and factory owners in many places, *e.g.*, Lyallpur, have not bid at our auctions for two or three years. With the assistance of Mr. A. J. W. Kitchin, C.I.E., Deputy Commissioner of Lyallpur, the Department drew out a series of rules and conditions regarding "weighments," "allowances," and "arbitration" to remedy some of the above abuses and these have worked with conspicuous success. The cultivator is beginning to realize the advantages of "co-operative sale" and great developments in this direction may be expected in the future.

(*d*) In spite of assistance through auctions it had been noted that prices in outlying markets which were some distance from Lyallpur tended to be well below Lyallpur prices. To remedy this partially at any rate, it was decided to post up Lyallpur and Bombay prices daily at the chief markets. The idea is to keep zemindars informed of the real value of their produce and of the general trend of the market. There has been a marked effect already and in all outlying markets prices have advanced closer to Lyallpur prices. At Tandlianwala which is about 40 miles from Lyallpur by road and over 100 miles by rail, prices up to this year were sometimes as much as Rs. 2 per maund below Lyallpur prices, but in the present year have not been more than As. 6 per maund lower. The effect in the Lower Bari Doab has been

even more pronounced and has in consequence reacted very favourably on the growing popularity of cotton as a crop.

(*e*) Much of the American cotton produced in the Colonies was sent to Bombay mixed with *desi* cotton, the latter being put in to the extent of 10 to 25 per cent. and sometimes even more. This mixing was partly accidental owing to over-crowding in ginning factory compounds and also mainly deliberate. Zemindars grow these cottons pure nowadays, and it is rare to see a field of American with over 5 per cent. *desi*. It is easy to detect mixture in the *kapas* and zemindars are heavily penalized both in the Department's auctions and by factory owners for admixture of *desi* cotton; hence the rapid disappearance of mixtures in the field. When the cotton is ginned it is very difficult to detect even 10 per cent. mixture, and hence mixture in baled cotton is not uniformly or adequately penalized in Bombay. This practice must ultimately affect every one, even those who try to send American pure to Bombay. A remedy must be found up-country. Ultimately no doubt it will be necessary to license ginning factories and use this handle to penalize mixing. As a first step in remedying this and other evils, the Punjab Government have accepted certain suggestions of the writer regarding conditions under which any new factories can be built. Probably some sort of combination among factory owners in the form of an Association which could be recognized in Bombay is the only reliable and constructive manner of tackling this difficulty. Membership of this Association would involve responsibility and an undertaking to send cotton of definite purity. The penalty for breach of these conditions would have to be a heavy fine or loss of membership. Such an Association would command confidence in Bombay and

be to the interest of ginners themselves as well as that of zemindars.

(*f*) *Pure seed.* With concentration on one type, *viz.*, 4 F, the whole of the American cotton will in time become standardized. Already over half the American cotton grown here is of this variety, and the proportion will increase greatly in the next two or three years. The Department hopes to sell enough seed for 200,000 to 250,000 acres of this type in the coming season. The seed is sold at a premium of 40 per cent. and covers all expenses involved in premiums and in supervising ginning, etc. As the seed rate is only 8 lb. per acre the increased price of seed amounts to only As. 3 per acre and farmers gladly pay the necessary premium. It is possible that a better type than 4 F will be forthcoming. In the course of a few years it will certainly improve as selection is carried through. Owing to the existence of a number of large estates in the Colonies there will be no difficulty in keeping seed pure. A good deal of attention must be concentrated on this work as it will become of growing importance as time goes on.

(*g*) The greater the quantity of a good class of cotton which can be grown the easier it is to secure fair prices for the produce. So long as the quantity is small only a few buyers can secure the cotton, and competition is in consequence much restricted. With the extension of irrigation the area under American cotton will, of course, increase, but at present an area of 450,000 acres will represent the limit in sight. Cotton undoubtedly pays better than wheat in the Western Punjab, and, in the case of American cotton, farmers are beginning to realize that it is a very safe crop.* The great question of increasing summer

* See paper by the writer on this subject contributed to the Punjab Irrigation Congress, 1918.

supplies in the canals when the rivers are in flood is becoming therefore of even greater importance than formerly. This is a matter of very wide and deep significance to the future prosperity of the province. The foundation for the success of such a policy is being laid in the introduction of American cotton. Immense developments are possible in this respect in Sind also, where staple cotton of much finer quality than can be grown in the Punjab only awaits the advent of a secure irrigation system. Such development in Sind would react beneficially on the Punjab as it would tend to raise the price of Punjab-American.

THE CONSOLIDATION OF AGRICULTURAL HOLDINGS IN THE UNITED PROVINCES.

BY

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(Continued from page 230, vol. XIII, pt. II.)

PART II. OUTLINE OF PROPOSED CHANGES.

THE first part of this paper has been devoted to an exposition of the more important economic principles affecting the consolidation and enlargement of agricultural holdings and to defining and finding a solution in general terms of the problem of estabiishing permanently a higher standard of living. The practicability of attaining these objects has purposely been left unconsidered. It was intended only to obtain a clear view of the right goal to aim at; because such a clear view is necessary before the practical measures to be taken for the purpose of changing the present evil can even be discussed fruitfully. Also in order to obtain a simple and clear view of the object to be aimed at I purposely avoided details; and these may in some cases be filled in here.

CONSOLIDATION OF ALL OWNERS' HOLDINGS NECESSARY.

It is necessary to distinguish between the scattering of the strips of one *mahal,* or legally recognized unit of ownership, and the scattering of strips held by one cultivator, whether from one or more owners. For clearness of diction I use the term *unit of cultivation* to denote the whole of the fields actually cultivated by one man, or by a family or partners, as one business concern, whatever the ownership of fields may be. The cultivator may hold some of his

fields as a tenant with occupancy rights, and others as a tenant-at-will, and himself own yet other fields, thus making up a cultivating unit of, say, 10 or 12 acres. The scattering of strips in ownership* would not be a matter of vital concern were it not that it involves almost of necessity the scattering of the fields of a cultivating unit, because a tenant would experience very great difficulty in making the numerous agreements which would be needed to get a consolidated cultivating unit. I come, therefore, to the conclusion that the only practicable course is to adopt a policy of abolishing both scattered ownership and scattered tenants' holdings at the same time by consolidating the units of ownership.

In cases when the ownership is not at present scattered—that is to say, where a whole village, or a large part of a village, is held as one *mahal* by a 16-anna shareholder, or in imperfect partition—it would seem to be feasible for the owner, or the two or more shareholders, to agree to rearrange the holdings for letting purposes. One obstacle to this is the novelty of the idea, and the consequent opposition which would be raised even by tenants-at-will as a united body; and a further obstacle is the absence usually of any expert agent to carry out for the landlord the re-division of his land into the fresh holdings. The land needs to be re-surveyed, and new holdings graded in size according to the quality of the land, distance from the *abadi*, etc. The principal difficulty, however, is the occurrence of occupancy holdings with their fields thoroughly intermixed with the fields of tenants-at-will. The occupancy tenants cannot, under the present tenancy law of the Agra province, be bought out; and it is exceedingly difficult to arrange an exchange of fields which will be regarded by occupancy tenants as mutually satisfactory. Consequently nothing is done.

ADVANTAGES OF CONSOLIDATION ADMITTED.

Yet scattered holdings are admitted to be a serious evil which is frustrating the progress of agriculture in several parts of India.

* Both *mahals*, and *pattis* thereof, are frequently composed of scattered fields different parts of the village.

I take it to be generally agreed by agricultural experts that it is desirable in most places to consolidate scattered holdings more or less completely, the idea being that a holding should be compact, except where the nature of the country is such that the safest and most economic business is to carry on a mixed farming requiring river meadow lands, and plains or uplands in due proportion.

The disadvantages of the present condition of holdings and the advantages of re-stripping have been so well stated by many authorities that I need do no more than indicate my agreement with their statements. In 1912, Mr. Moreland, then Director of Land Records and Agriculture in the United Provinces, prepared a note for the United Provinces Government[1] which was printed and circulated by this Government. His proposals will be considered later on in this paper. In the same year Mr. G. Keatinge dealt briefly with this question in the Deccan.[2] In 1916, Mr. Burt read a paper before the Science Congress at Lucknow on "The Re-alignment of Agricultural Holdings";[3] and more recently a committee appointed by His Highness the Gaekwar of Baroda has fully investigated the question of the minute subdivision of holdings in that State.[4] Dr. Harold Mann has also called attention to the evils of excessive subdivision and cultivation of scattered fragments of land. He points out that cultivating a holding of small scattered fields has the great disadvantage of very small holdings in preventing the use of machinery and labour-saving appliances, whilst also "it has all the evils of large holdings, in that it prevents the adoption of really intensive cultivation by any holder."[5] In a subsequent publication he has amplified this study.[6] The importance of the

[1] Dated 29th June, 1912, and enclosed under No. 19 I-505-1912 of 1915.

[2] *Rural Economy in the Bombay Deccan* (Longmans), pp. 40-2, 51-5.

[3] Reprinted in the *Agricultural Journal of India*, Special Indian Science Congress Number, 1916, p. 33.

[4] *Report on Consolidation of Small Scattered Holdings*; issued by Baroda State Printing Works. As. 10.

[5] "Economics of a Deccan Village." *Indian Journal of Economics*, vol. I, p. 420. Reprinted in the *Agricultural Journal of India*, July, 1917.

[6] *Land and Labour in a Deccan Village*; University of Bombay: Economics Series No. 1 (Oxford University Press), 1917—Chapter III: The Land and its Divisions and the Holdings.

question is being widely recognized in the Bombay Presidency and it has received attention in the Bombay Legislative Council on more than one occasion during the past two years.[1]

SCATTERED STRIPS CHARACTERISTIC OF PRIMITIVE SOCIETY IN ALL COUNTRIES.

The cultivation of scattered strips is a well known and very widely distributed economic phenomenon which seems to be characteristic of a certain stage of the evolution of primitive society in all races of mankind. The first three stages of the evolution of society are (1) families living by hunting and gathering wild fruits; (2) nomadic tribes living by pasturing domesticated animals, and gathering wild vegetable products; (3) "extensive" cultivation, as it is called by economists.[2] Nomadic tribes, having learnt to take occasional catch crops, gradually settled down and began to break up patches in the jungle. They had no rotation of crops, but broke up new patches in the waste as required.

The *abadi* is characteristic of the most primitive agricultural people. They settled in a definite spot for the village, and thus came a fourth stage. All the lands near the *abadi* became cultivated by the growing population of the village and the children of large families divided the home fields and had to make their cultivated area up to a size sufficient for maintenance by taking in fields from the waste. The fifth stage is the almost complete absorption of the cultivable waste, except what is needed for grazing land; and the sixth stage, the subdivision of holdings through the growth of population until the minimum economic size is reached, corresponding with a slightly improved cultivation which is forced on the people for maintenance. Here a stage of economic equilibrium is reached in which population must be stationary and the death-rate equal to birth-rate on the average, though owing to variations of the seasons,

[1] Proceedings of the Bombay Legislative Council; especially the 14th and 15th March, 1916.

[2] Cunningham, W. *Growth of English Industry and Commerce during the Early and Middle Ages*, 5th ed., p. 33. *Cf.* Bucher. *Industrial Evolution*, Trans. Wicket (Holt & Co., N. Y.), pp. 45 *et seq.*

it is largely by famines and epidemic diseases that the average death-rate keeps the population down.

This is the last stage characteristic of primitive civilization, and society may remain in this condition for centuries. When advanced civilization begins to demand progress of the agricultural community, two lines of advance are possible : (1) by education and co-operation, and particularly by instruction of the people in the methods of intensive agriculture, so as to increase the productivity of the small scattered holdings, as has been done in France, Japan, Denmark and Ireland ; (2) the other line of advance is to promote improved efficiency in agriculture by a re-arrangement and enlargement of holdings. The former method would appear to be very limited in its scope—in economic phraseology, the marginal productivity of additional effort devoted to improving the culture of small holdings declines rapidly. The only exceptions are in places where there is a particularly large demand for special crops, *e.g.*, the environs of Paris, London, or Calcutta.

For the production of the staple crops the economies of large scale production on compact holdings are so great that small holders of scattered fields can hardly make a living in competition, where the market is ruled by a considerable volume of production on a large scale. They are handicapped not only in labour, but by the difficulty of employing capital in the form of machinery and permanent improvements. This is well understood in England. It is easy, therefore, to establish two propositions : (1) that the progress of national economy, that is the welfare of the country as a whole, demands the cultivation of all staple crops on large holdings with abundant capital, because of the great economies, and therefore increase of wealth, which would thus be realized ; and (2) that if large holdings become numerous in some parts of India, *i.e.*, Punjab, Central Provinces and parts of the United Provinces and Bengal, the system must rapidly (that is in 20 years or so) be extended throughout the whole of India, because the cultivation of staple crops on small holdings will become so unremunerative as to yield less profit than will support the existing standard of living.

NECESSITY FOR GOVERNMENT INTERVENTION.

It may be admitted that the economic welfare of India requires the introduction of the system of cultivation on large compact holdings, and yet be questioned whether there is need for Government intervention in the matter. It may be answered at once that it is highly probable that, were it not for the very great economic friction created by the primitive land tenure customs and laws, the change would have come about already. Unfortunately the effect of British legislation in India, which created occupancy tenures and permanent ryotwari and zemindari holdings, has been greatly to increase the difficulty of change; and it may be confidently asserted that the difficulty of re-arranging and enlarging holdings is now so great that the expectation of a profit three times greater than that which may be fairly anticipated would not be a sufficiently powerful economic force to bring about the change. It is, therefore, essential that the Government should intervene, and by means of special legislation facilitate the consolidation and enlargement of holdings.

The experience of other countries supplies ample precedent for the special intervention of Government to secure this end. In all countries the last stage of primitive tenure involves not only an intermixing of fields, but common rights in grazing on the pasture and waste, and, sometimes, on the stubble. Such rights have everywhere proved too complex and stubborn to be liquidated by agreement over any large area of country, and special legislation has proved necessary. The pioneer country in this special legislation was England; but many other countries have been obliged to undertake special legislation as noted above. As the change has been carried practically to completion in England it will be profitable to glance briefly at the methods which were adopted and the results obtained in that country.

THE ENCLOSURE MOVEMENT IN ENGLAND.

In England the consolidation and enlargement of holdings was nearly always accompanied by the erection of a ring fence about the new holding, which was usually partly carved out of the common land. Hence the process variously called re-stripping, re-alignment,

consolidation, redistribution, re-partition, or reorganization, was in England termed "enclosure." The type of cultivation, which was practically universal in England during the Middle Ages, is known as the "open field system." The lands of the manor (or village, as we should call it in India) were classified as follows: (1) the demesne close (or private compound and home fields of the lord of the manor); (2) arable fields; (3) meadow land, beside a stream or river; (4) common pasturage on which the villagers had limited grazing rights; (5) waste, with unlimited free grazing until later centuries when the growth of arable and pasture absorbed most of it; (6) forest, with well-defined rights of the villagers for taking fuel and timber. The villagers, whether free-holders, villeins in servile tenure, or tenants-at-will of the former or of the lord of the manor, cultivated a large number of strips scattered throughout the arable fields, the number of separate strips being from 4 or 5 up to 50, but the most frequent number was probably about 20. The standard size of strip was the acre, 220 yards (one furlong) in length and 22 yards wide; but half and quarter acre strips were not uncommon, besides irregular plots caused by the contour of the ground. The acre was supposed to be the area which one plough with four, six or even eight oxen, could plough in a day, and as no cultivator owned as many oxen as were supposed to be required for the plough, a co-operative system of assistance prevailed. Whilst the demesne (equivalent to *sir*) lay partly in enclosed home fields, the larger part of it was in scattered strips in the open fields. The arrangement of the strips in the arable fields is well shown in a map published by Mr. F. Seebohm in his book "The English Village Community."[1] The best description of the English field system prior to the enclosures is to be found in a recent book by Professor H. L. Gray of the Harvard University.[2] He reproduces a number of maps of old parishes showing clearly the arrangement of the strips in the arable fields and the manner in

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[1] See frontispiece and plate opposite page 26. The latter plate is also reproduced by Cunningham, *ibid.*, page 44. I have relied considerably on Cunningham's account of the mediæval system of agriculture and would refer readers particularly to pp. 73-8 and pp. 526-34. An elementary sketch of the manorial system is contained in Gibbin's *Industrial History of England* (Methuen), pp. 5-22.

[2] *English Field System* (Harvard University Press), 1915.

which enclosures usually began to be made around the village dwellings which were concentrated in one place along one or two roads. Other sporadic enclosures of the meadow land were made for pasturage purposes, the initiative being usually taken by the lord of the manor enclosing part of the demesne.

The manner of cultivation differed in various parts of England and changed slightly in the course of centuries. The more primitive method was known as the "two-field system," and it involved letting the land lie fallow every alternate year. The arable strips of the village were grouped in two open fields, perhaps 200 acres or more each. In one year all the cultivators were obliged to leave all the strips in one of the fields fallow because the cattle were turned out to graze on the fallow land, and so the whole of their cultivation was done in the strips of the other field. Next year the fields were changed. A gain of cultivating an additional one-sixth of the total area was made by adopting a three-course rotation which involved the arable lands of the village being laid out in three fields, and was termed the "three-field system." Each field was laid fallow in succession so that each of the three fields was put through the following rotation:—

(1) Ploughed and sown with wheat in October, reaped the following August; grazing on stubble during autumn.

(2) Ploughed in March and sown with barley, oats, beans or pulse; grazing on the stubble during the autumn.

(3) Land ploughed twice, but lying fallow, and open to cattle.

The three-field system seems to have gradually superseded the two-field system except in certain districts where the latter remained until both the systems gave way before the modern method of convertible husbandry in which periods of grass growing alternated with arable culture. It was the profit of sheep farming and cattle breeding which first led to the withdrawal of lands from the common cultivation and their enclosure with fences. This movement began in the east of England in the fifteenth century and resulted in a considerable depopulation of certain parts of the eastern counties. The incentive of sheep breeding did not extend over the rest of the

country, and probably also there were greater legal difficulties in making enclosures in other parts of England, a larger percentage of land having been freehold originally in the eastern counties. Sporadic enclosures took place throughout the sixteenth century, but it was not until proper ideas of convertible husbandry and drainage were learnt from the Dutch in the seventeenth century that a widespread interest in the consolidation of holdings and their enclosure began to be evinced.

The best account of the enclosure movement is given by Professor Gonner in his book "Common Land and Enclosure" (Macmillan, 1912). He has traced from contemporary documents the whole course of the movement and has described the legal methods adopted at various times to carry out the enclosures. In the seventeenth century, the enclosures were mainly carried out by agreements of the owners, which would mean the lord of the manor, the copyholders and one or two free-holders. It was usually considered necessary to render the agreement indefeasible by obtaining a decree of the Court of Chancery. A few extracts from Gonner's book will be of interest.

"During the seventeenth century, agreements were even more important. The testimony as to their prevalence is strong and spread throughout the period. They find mention in the record of the action of the Privy Council, between 1630 and 1640, which illustrate the difficulties which beset those anxious to agree, and also the methods whereby a reluctant consent was often wrung from those who were unwilling. Again, in the controversy which raged a little later as to the effect of the enclosures in the Midlands, and particularly in Leicester, we are told of the lords of the manors and others anxious to enclose that if they cannot persuade, they commence a suit in law." [1]

The difficulty of this method was that "the decree would not affect rights which were claimed by others than the parties to the case...... It may be suggested that it was the recognition of this limitation which led to the disuse of this particular method. Its

[1] *Ibid.*, pp. 53-4.

inability to procure anything like a binding or universal consent, together with the difficulty attending purely voluntary, and even registered agreements, led to the open and steady demand for powers to prevent obstruction which could be obtained only by application to Parliament."[1]

"This new stage on which enclosure enters under parliamentary authority admits of division into three periods. During the first, which extends through the eighteenth century to the general act of 1801, the growth of the private acts may be traced from the very rudimentary form of the earlier acts to that high degree of development where, by reason of the very uniformity and complexity of the provisions included on each occasion, a general act was rendered not only feasible and useful but essential. The second period is from 1801 to 1842-5[2] and includes the private acts which were passed in accordance with the provisions of the general act. After 1845 the powers hitherto exercised directly by Parliament, and through commissioners specially appointed by act, were delegated to different permanent bodies established by act, and subject to Parliamentary control, inasmuch as their decisions or orders had to remain on the table of the Houses before becoming operative."[3]

The usual procedure in making enclosures by private act was, at the close of the eighteenth century, when the technique had fully developed, as follows.[4] Proceedings were commenced by a petition for an act, which involved considerable expense whether the act was ultimately obtained or not, and this placed the initiative in the power of wealthy owners only. A meeting of owners and others known to be interested had to be called and a preliminary agreement of all those who could be got to agree to submit their interests to commissioners sanctioned by Parliament was included in the petition. In most cases the commissioners, usually three in number, were named in the petition or draft bill. The commissioners were usually paid. Probably the best "were practical men with knowledge of

[1] *Ibid.*, pp. 55-6.
[2] That is, to the general act of 1845.
[3] *Ibid.*, pp. 59-60.
[4] This is abstracted from Gonner, *ibid.*, Book I, Chap. III.

farming and surveying, who gained experience from being employed in enclosure after enclosure."[1] The powers of the commissioners were considerable and each was bound by oath to administer with justice. Their award was final, except as to the title to property. The local proceedings were arranged with a view to publicity, and usually opened with a public meeting to consider the draft petition. After such negotiations and meetings as proved necessary, signatures of the draft bill were obtained and witnessed, showing the degree of dissent, if any ; and the act was then usually passed by Parliament with little or no alteration, if in the usual form.

The commissioners being now appointed called a public meeting at the locality, at which they usually took the opportunity of obtaining public consent, or at least hearing objections, in regard to the surveyors and valuers they proposed to appoint. The survey and valuation, the latter parcel by parcel for every holding, were then made. Besides fertility of the soil, drainage, situation and cost of enclosing were always taken into account. The proposed allotment of new fields was then made, and a revaluation of the land on this basis. Upon the improvement of value thus ascertained was first assessed the cost of the enclosure ; and then the rights of tithe, various rights of the lord of the manor, and of the forest ranger, etc., were compromised. The commissioners then proceeded to lay out the village anew, apportioning land of amount corresponding in the proportion of new total value with the proportion of estimated value of the previous rights of each recipient. "The new enclosures were as a rule regular and compact.... They lay, in the case of some, at a considerable distance from the little village of farm houses, while others had the advantage of having their holdings conveniently near."[2] One of the most important duties imposed on the commissioners was the laying out of roads, which were to be planned before the land was distributed. The public roads were to be constructed at the common charge of the enclosure. Private roads for access to holdings were planned by the commissioners and the expense apportioned by agreement amongst those whose holdings they served.

[1] *Ibid.*, p. 75.

[2] *Ibid.*, pp. 82-3.

"There is no doubt that the roadmaking performed under the enclosure acts co-operated with the increase in and improvement of roads under the Turnpike acts [1] in effecting the great change in the means of locomotion which marks the end of the eighteenth century." Fencing or hedging of the holdings was required to be done, and this bore heavily on the owners of small allotments, so that they frequently had to sell their rights to large holders.

The expenses of enclosure were heavy and caused loud complaints by the smaller owners. The Board of Agriculture has calculated that the average area affected by the acts was 1,162 acres each ; and that the average expenses were as follows :—

	£
In obtaining the act	497
Survey and valuation...	259
Fees of commissioners and pay of clerks, etc.	344
Fences	550
	1,650

This amounts to an average of £1 8s. 1d. (or Rs. 21-1) per acre ; but apparently it does not include the assessed cost of roads. The appreciation of value was considerably more than this for the larger holdings ; but hardly equal to the expense for the smallest of the new holdings.

The subsequent history of the new compact holdings is one of gradual consolidation and enlargement. Immediately the redistribution was effected and the land fenced, many cottagers and small holders found themselves possessing a field of 5 to 10 acres, or two fields aggregating 15 or 20 acres. They failed to make them pay, got into debt and sold their holdings, usually to the lord of the manor, who threw such additional fields into his compact farms on

[1] "Turnpike Trusts originated in the desire to maintain and improve roads. In many cases, however, they are directed to the provision of new roads (see pp. 1851, xlviii ; County Report, Kent). While the first act was in the seventeenth century, such acts are scarce till Anne, and not really plentiful till towards the end of G. II., thenceforward they are very numerous. The trusts were usually for limited periods, but these were open to renewal. By the beginning of the eighteenth century, the length of road under Turnpike Trusts was about 17,000 miles (in 1818, 17,601, Parl. Papers 1818, xvi. ; in 1821, 17,329, Parl. Papers, 1821, iv.), of course the majority of roads were not under such trusts, other roads being given in 1818 at 86,116 miles."

which he was proceeding to build farm houses and buildings. For the first few years after enclosure all the cultivators, except the farmer of the old demesne, probably continued to live in the village and go daily to their new fields. But with the gradual formation of larger farms, involving a considerable household working at one centre, there was a movement to secure a residence on the holding itself, and as fast as landlords could find capital for building farm houses the exodus from the village high streets took place. It is important to notice that holdings of less than about 40 acres in area were generally located as near the village site as possible. With the formation of larger farms many of the objections to isolated residence disappeared because there was usually a larger family and several relatives and hired labourers living on the farmstead. These numbers gave increased security, and a sufficient degree of social intercourse, if supplemented by visits once or twice a week to the village or market town. During the first three-quarters of the nineteenth century the movement for increasing the size of farms seems to have continued in England, two or three small farms of fifty to one hundred acres being thrown together and let as one. One of the farm houses and appurtenant holdings would be greatly enlarged, and those of the other holdings be dismantled, or be let as residences with garden and paddock if anywhere near a town.

It is worth noting that a vast improvement in the intelligence and class of youths who remain to work on farms in England has occurred during the past 15 years by the cheapening of the bicycle whereby they can meet daily in the evening in the village. It is not difficult to imagine how, in rural India, social life would be raised to an altogether higher plane, were the holdings to be sufficiently enlarged and methods of cultivation improved so that the majority of villagers could afford to own bicycles, and if inter-village roads were all metalled so that they could use them. The Indian villager is fond enough of gadding about if he gets the opportunity ; and it is difficult to overestimate the educational value of local as well as distant travel. Nothing would more rapidly diffuse an interest in and knowledge of improved methods of cultivation.

Mr. Moreland's Note.

In his note referred to above, Mr. Moreland first indicates the advantages which would accrue from a re-distribution of holdings; and then rightly points out that the present waste of power becomes more serious as the cost of production increases. He regards it as desirable that experiments should be made in villages where conditions are favourable, and proceeds to outline a method of proceeding by arranging exchanges of fields. He then suggests that if it were "found possible to make the bulk of the holdings in a village fairly compact," the question of moving homesteads out would arise. "Where the holding is at a long distance from the village, the cultivator might decide after discussion to build a house on it." He next refers to the necessity of retaining the uneconomic holding (in due proportion) as a ladder by which the best and thriftiest labourers can mount to the rank of cultivator. The next paragraph is important: if the result of experiments as above indicated should be negative, the question would then arise of passing an Enclosure Act giving landholders the power to override the opposition of a minority and reorganize their villages with a clear course open. Finally he deals with the question of increasing the size of holdings.

The criticism of this last section of the note relating to the size of holdings must depend entirely on the critic's premises. Mr. Moreland writes as if looking at the question from what I hope I may call the old-fashioned point of view. The question with him is whether external economic forces will force attention to the size of holdings as a serious social evil through the margin between price and cost of production becoming less than a subsistence minimum. He thinks there is no reason for immediate anxiety, and hails the co-operative movement, especially co-operative purchasing and marketing, as a means of at least staving off, if it cannot permanently prevent, such a calamity.

Objects of proposed changes.

My own object in the proposals which I shall make in the remainder of this paper is a very different one from that which may be inferred from Mr. Moreland's note; and I would submit that it

is of fundamental importance to have clearly in view the object of any proposed measures before judging them, and that it is always necessary to decide definitely upon the aim of any reform under consideration before proceeding to discuss what changes are needed and how they are to be carried into effect.

In the measures which I shall now tentatively outline I keep constantly in view as their object the deliberate and progressive increase of the welfare of the Indian people.

The economist is directly concerned with two ways of realizing this end:—

(1) By the development of the economic resources of India with the utmost rapidity consistent with safety in assuring permanence of the results obtained.

(2) By the provision of the physical basis for progress to a higher standard of life—intellectual, religious, moral, and social—by indicating—

(*a*) how to utilize for this purpose with the greatest efficiency the wealth produced by the development of resources;

(*b*) how the material environment, as regards dwellings, towns, roads, water-supply, public works, and so forth, may be arranged so as to react with the greatest effect in the desired direction of intellectual, moral and social uplift.

There can be no question but that the right line of advance in developing the resources of India is to utilize the machinery of Government in order so to rearrange the land tenure system as to enable the existing body of skill and knowledge of the agricultural art possessed by the cultivators through tradition and by numerous trained experts, and the existing supply of capital in both private and State control, to be employed with the maximum of efficiency in the production of wealth. At the same time in devising measures to this end care should be taken that there is not a serious loss of character and other beneficial qualities of the agricultural population by the social revolution that must be caused, but rather that the measures taken for the production of wealth tend at the same time

to the upbuilding of the more perfect man. As a step in this direction I proceed now to define the type of rural community which appears to me to be a realizable ideal for the near future, and a very distinct advance along the road which I have indicated.

I would like to say at the outset that my views on this question were only formed after a visit last year to the Lower Chenab and Lower Bari Doab canal colonies. I very much doubt whether any one who is not familiar with the wonderful canal colonies of the Punjab will have the faith that has been born in me as to the possibility of the rural regeneration of the rest of British India. In the remainder of this paper I shall refer only to temporarily settled tracts where zemindari system of landlord and tenant prevails as in the provinces of Agra and Oudh, the Central Provinces and parts of the Punjab. Much that I say will also be applicable to the permanently settled territories of the United Provinces, Bihar, and Bengal.

(*To be continued.*)

BLAST OF PADDY.

BY

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In Papanasam Taluk of Tanjore District in the Madras Presidency there was a marked shortage of this year's second crop of the variety of paddy (*Oryza sativa*) called Korangu Samba. The cultivators attributed the short crop to unwonted rain at the end of December when the plants were in flower, but this is an afterthought remembered at harvest-time to explain the shortness.

As an example of how small the crop has been in particular fields the information got in the village of Umaiyālpūram is interesting. Last year as a second-crop paddy Korangu Samba gave 1,008 Madras measures* per acre. This year one acre gave 720 M.m., of which 96 M.m. remained after winnowing. Another field of $1\frac{1}{3}$ acres gave 192 M.m., of which 20 remained after winnowing, *i.e.*, 15 M.m. per acre.

A ten-cent plot in a badly infected field in the village of Umbalapadi was harvested and winnowed in my presence. The yield consisted of $3\frac{3}{4}$ M.m. weighing 308 tolas (almost 8 lb.), *i.e.*, at the rate of $37\frac{1}{2}$ M.m. per acre. The owner said that the usual yield in a ten-cent plot on this land was 120 M.m. and the Tahsildar told me that the average for the taluk was 72 M.m. Before I arrived, most of the paddy had been harvested, and of what still remained on the ground this field was by far the worst I saw. Accordingly, though this experiment shows how great the loss can be, yet from it no estimate can legitimately be made of the loss over any large area and such an estimate I had no means of making, though figures

* One Madras measure contains 108 cubic inches, and one M.m. of paddy weighs $2\frac{1}{4}$ lb.

given me by the Tahsildar from the village officers' reports show that over an area of 1,687 acres in twelve villages the average yield of Korangu Samba was 216 M.m. per acre. In these villages, too, about 428 acres of this variety were sown as first crop, three-quarters of which were in two villages. The yield varied from 36 to 720 M.m. per acre, the average being about 264 M.m. This shows that there was considerable shortage in the first crop this year. Outside these villages there does not seem to have been much talk of short crop and the variety is said not to be widely grown in the taluk as a second-crop paddy.

Perhaps one can get a more impressive idea of the loss caused if it be given in money value on the basis of 12 M.m. to the rupee which was the price after harvest in February. In the two examples from the village of Umaiyālpūram given above, the shortage is 1,008 – 96 = 912, and 1,008 – 15 = 993 M.m. respectively, or Rs. 76 and Rs. 82 per acre. In the field from which the ten-cent plot was chosen the shortage is 1,200 – 37½ = 1,162½ M.m., or Rs. 97 per acre. For the 1,685 acres the loss is 1,008 – 216 = 792 M.m., or Rs. 60 per acre, while over the whole area it is 1,336,104 M.m., or Rs. 1,11,000. This is a very great loss indeed and bears out Metcalf's[1] expression that "from the standpoint of the amount of loss it causes it undoubtedly ranks with the grain rusts as one of the most serious plant diseases of the world."

According to the villagers, Korangu Samba was first tried as second-crop paddy in Ganapathi Agrahāram and was brought in 1915 from a village about 25 miles south, where it was grown as a single-crop paddy. The 1915-16 crop in the new conditions was a very good one. Being well spoken of it was tried on a larger scale next year and the crop was again good, being 960 to 1,680 M.m. per acre. This year, however, it has caused much disappointment. To some other villages it was introduced in 1916 from a village where also it was grown as a single-crop paddy. The first year's crop was a heavy one but this year it is very poor. Both these places of origin are outside the irrigated part of the Cauvery delta and the

[1] Metcalf, H., on pp. 99-105 of *The Diseases of Tropical Plants*, by M. T. Cook, 1913.

soils are higher and more freely drained. This would naturally lead to a deeper rooting habit in the plant and this may account for the high yields which this variety gave in the first one of two crops after being introduced to the heavy soil conditions of the delta lands, though the variety seems not to have been able to adapt itself permanently to those conditions after it had lost its initial vigour. Several people have declared that they will not grow this variety again. There is little likelihood of its being used in these villages and a note of warning has been given to ryots generally in the delta to avoid this variety in future on double-crop land.

Characters of the disease.

Small spots appear on the leaves and extend through the tissues of the leaf, appearing equally on both upper and lower surfaces. Reddish or brownish at first, the centre soon becomes pale yellow. The spots extend more rapidly in the longitudinal direction and may become one inch long by one-fourth inch broad. By this time the edge of the spot becomes pale brown, and ultimately the whole area of the spot becomes brown. Adjacent spots coalesce. The brown areas sometimes extend along nearly the whole of one side of the leaf-blade or they may extend across it and the leaf gradually withers. The central part of the spot assumes a soiled, smoky appearance owing to the presence of the sporophores and spores in abundance, and this occurs on both surfaces of the leaf. Spots are found on the leaf-sheath as well as on the leaf-blade, and may also involve the ligule. When a spot is present at the junction of the blade and the sheath this part often becomes very dark brown. When that part of the leaf-sheath immediately outside a node is infected the stem below it is sometimes infected too, becoming almost black at the node and for a short distance above or below it or both. The stem sometimes bends over at this infected node. When the leaf that encloses the ear-head is infected some of the glumes touching the spots become dark brown and the region of the stem below the ear-head becomes brown and ultimately almost black for a distance of about one inch. This discoloration also extends upwards into the lowest branches of the ear-head. Not

infrequently the stem collapses and breaks at this place and the ear-head hangs downwards. Apart from a few dark brown glumes the ear-heads usually look quite normal, yet the ears are seldom filled. They either have no rice-grains or very stunted grains though some of them may be filled normally. From the ten-cent plot in a badly-infected field in the village of Umaiyālpūram mentioned above, the grains of fifty ear-heads that had a dark discoloration on the stalk just below the ear-head but that looked otherwise normal were counted. There were 7,275 paddy-grains, of which 171 were full and these were found on nine ear-heads, *i.e.*, 2·3 per cent. of the grains contained rice-grains. Of the others a remnant of a rice-grain was present in each paddy-grain, but it was of no use as rice. In many cases, the people had no suspicion that the plants were abnormal and they expected a good yield. It was only when the coolies, paid in kind for their first day's work, complained that they got no rice from the paddy that the owners realized that their crop was short.

A considerable number of plants appear to have been attacked while in quite a young stage. The earliest formed leaves were covered with spots and were dried up as also were most of the later formed leaves. The plants were only about one foot high. They had very few stems with ear-heads and even these contained only empty grains. In other plants the main tillers had matured and there was a considerable amount of secondary growth of branches from them. The ear-heads of the latter showed arrested development and in many cases their branches were not expanded, but had remained together as they were in the stage when they protruded from the sheath. The ears very seldom contained rice-grains. These young branches as they were in all stages of development showed well the various stages of the attack. When a young branch had been attacked early, *i.e.*, before the ear-head had come out of its sheathing leaf, the leaves had numerous spots and were dried up and the ears were empty. The empty ear-heads stand erect and are conspicuous in the field when the normally matured ear-heads all bend over with the weight of the grain. When a branch had been attacked later, the spots occupied a small proportion of the leaf-surface and the ear-heads were comparatively well

filled, though some contained stunted half-formed rice-grains. On the other hand, some plants lightly attacked had well-filled ears. Thus a plant attacked in an early stage suffers worst while one attacked at a late stage of its development is but slightly affected.

In the early stage of the attack these characters are usually fairly definite, but as the general health of the plant becomes affected and it loses its green colour, the colouring of the diseased part becomes indistinct and the presence of the fungus is not easily recognized on the blackened, faded and discoloured leaves and stems which become invaded by various saprophytic fungi.

The characters of the disease found on Korangu Samba were also seen to a small extent on Kārun Kuruvai, Chinna Sirumani, Vellai Sirumani, Thōga Samba and Tanga Samba though not on Tillai Samba, but there is no complaint of short crop on any of these. Two plants of Chinna Sirumani were found in the field from which the ten-cent plot was chosen but they did not have the disease.

The fungus *Piricularia oryzæ* was found on the spots on all positions in which they were found on the plant, *viz.*, leaf, node, stem, ear-head and glumes, and in all the varieties noted. Its hyphæ penetrated the cells of the various tissues and were found in abundance. The sporophores protruded in groups of two to four from the stomata and nearly every stoma on a spot had its quota. The spores were formed singly at the end of the sporophore. When one spore is shed the sporophore grows a little and produces another and five may be produced in all, though in culture 17 have been formed on one sporophore. When looked at through a lens the surface of the spot appeared to be covered with a brown delicate network, which consisted of sporophores and spores. The spore is pale yellow and pear-shaped, and at the broad end is a slight protuberance that attached it to the sporophore. Each spore has two cross walls dividing it into three cells. They germinate readily in water. Two hours after immersion they begin to germinate, and in eighteen hours have produced long branching hyphæ sometimes with spherical resting spores with slightly thickened walls and dense protoplasmic contents. Metcalf says that the three-celled spores

rarely survive over three months, but that the resting spores may survive at least twenty months. There is thus ample opportunity for the fungus to live over the dry weather and infect the next crop.

The fungus has been declared to be the cause of Brusone in Italy by Cavara and Farnetti, of rice-blast in the United States of America by Metcalf and Foulton, and of Imotsi in Japan by Kawakami. In these countries it has done a very great deal of damage.

Seeing that paddy as it is grown is not adaptable to ordinary preventive measures like spraying, any method of control of the disease will have to be along cultural and selective lines. There seems to be a consensus of opinion among those who have investigated the disease that nitrogenous fertilizers render varieties of paddy more susceptible to the disease and this will have to be studied under the local conditions in Tanjore. The success that has attended the production of resistant varieties in other countries, especially Italy, is encouraging, if the disease becomes a menace to paddy cultivation in this country.

EXHIBITS OF THE GOVERNMENT AGRICULTURAL CHEMIST, MADRAS, AT THE MADRAS INDUSTRIAL EXHIBITION, DECEMBER, 1917.

BY

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A CIRCULAR was received from the Director of Agriculture, Madras, on 15th August, 1917, stating that an industrial exhibition would be held at Madras during Christmas, the main object of which was to encourage the manufacture in this country of articles hitherto imported, and the Government Agricultural Chemist was specially asked "to make endeavours to show articles of food prepared from local agricultural produce which could replace similar imported articles." The ordinary departmental work was at once stopped and the whole of the staff turned their energies on to this problem.

So far as food products were concerned, it was felt that the primary problem was the production of a good malt and malt extract, as these are important constituents of many patent foods. The scope of the work was extended so as to include other substances than foodstuffs and the articles finally prepared for the exhibition may be classified as follows:—

A. Infant and invalid foods.
B. Breakfast and other foods.
C. Flours and starches.
D. Beverages.
E. Casein and casein products.
F. Miscellaneous.

A. INFANT AND INVALID FOODS.

The search for a grain of good malting capacity. Malted foods claimed first attention in the laboratory. As barley, which is the cereal grain almost universally used as the base for the preparation of different malted foods, is grown only to a small extent in Madras, a substitute for barley was sought for amongst the important cereal grains of the Presidency, *viz.*, paddy (*Oryza sativa*), *cholam* (*Sorghum vulgare*), *ragi* (*Eleusine coracana*), *cumbu* (spiked millet) and *tenai* (*Setaria italica*).* These grains were each malted and their diastatic activity determined and compared; the experiments showed that *cholam* and *ragi* malted as well as barley. The malting process was carried out in the following manner:—

A quantity of each kind of grain was soaked in water for 24 hours, drained and spread in large tin trays to germinate, the trays being covered with a wet cloth to preserve a moist atmosphere. After three to five days when the radicles were prominently visible and had attained a length of about ½ inch, germination was arrested by first drying in the shade for two days on the stone floor of the verandahs and then in the sun for one day, after which the malted grain was ground in a laboratory sampling mill.

The diastatic activity of each malted meal was determined as follows:—

Fifteen grams of the malt were digested with 250 c.c. of water at room temperature (average 28°C.) for four hours. The extract was filtered, the first portions being rejected. One c.c. of the filtrate was added to 15 c.c. of a 2 per cent. solution of soluble starch, and, at the end of one hour, the starch solution was tested with iodine. In the case of *cholam* and *ragi* no starch remained, but in the case of others starch was present and had not been

* According to the Agricultural Statistics of the Madras Presidency for 1916-17, the normal acreages of the above crops were:—

	Acres
Paddy	10,687,950
Cholam	5,407,450
Ragi	2,502,350
Cumbu	3,509,120
Barley	3,120

completely hydrolysed even after twelve hours, thereby indicating that *cholam* and *ragi* malted better than paddy, *cumbu*, maize, or *tenai*. Preliminary experiments showed that *cholam* and *ragi* were a little superior to barley in diastatic activity as shown by colour reactions with iodine. Further investigations regarding the differences in diastatic activity of barley, *cholam* and *ragi* and of the sugars formed by hydrolysis therefrom have been carried out and submitted for publication as a memoir in the chemical series.[1]

The malted *cholam* and *ragi* thus prepared were utilized for the preparation of several types of patent foods.

Benger's food type. The coarsely ground *cholam* and *ragi* malts were sieved in a 100-mesh sieve to remove husk, mixed separately with arrowroot starch in the proportion of 3 to 1 and bottled air-tight. Thus were obtained two substitutes for Benger's food, one from *cholam* and another from *ragi*. The prepared foods had the same properties as Benger's and, when prepared according to the directions given on the Benger's food bottle, were found to have all their starch hydrolysed.

Malt extract. Four hundred grams of *cholam* and *ragi* malts were each extracted with 1,200 c.c. of water at room temperature for three hours, filtered through muslin, clarified with kaolin and filtered, and the liquor evaporated *in vacuo* at a temperature of 40–50°C. and at a pressure of about 50 m.m. so as to prevent the destruction of the diastase. While the evaporation of the diastatic liquor was proceeding, the residue on the muslin was transferred to a large flask with water and quickly raised to boiling, whereby the starch became gelatinized and the proteids coagulated. This gelatinized starch solution was filtered through a percolator and added gradually to the evaporating malt liquor, so that hydrolysis of starch took place simultaneously with the evaporation of the liquid. As soon as the contents of the distilling flask became sufficiently thick which usually took from 12 to 15 hours in the improvised apparatus, the malt extract was poured out into stoppered bottles. The

[1] Memoir vol. V, no. 4 of the Chemical Series, by B. Viswanath, T. Lakshmana Raw and P. A. Raghunathaswami Ayyangar. (*In the press.*)

specific gravity of the extract thus obtained was 1·30 and, in order to imitate the colour and the caramel odour of the imported article, baked starch was added in some cases during the evaporation process. Malt extracts prepared from both *cholam* and *ragi* have kept well for over six months.

Mellin's food type. To the diastatic liquor referred to in the preceding paragraph, gelatinized starch solution was added in the proportion of 1 of malt liquor to 2 of starch solution and the whole evaporated *in vacuo*. The residue was dried *in vacuo* and then powdered with some lactose, forming a satisfactory substitute for Mellin's food.

Horlick's malted milk type. Partially skimmed milk containing 1 per cent. of fat was evaporated and dried *in vacuo* at 50°C. The dry residue was powdered, mixed with desiccated malt extract (*i.e.*, Mellin's food) and sodium bicarbonate in the proportion of 69 : 30 : 1 and quickly bottled.

Sanatogen, Plasmon, and Eucasein types. Casein being the chief proteid material in milk and possessing good keeping qualities, if carefully prepared and stored dry, several patent foods have been prepared from casein and placed from time to time on the market under different trade names, *viz.*, Lactarine, Guttman's nutrient milk powder, Sanatogen, Eulactol, Eucasein, Plasmon, Dr. Reigl's milk albumen, etc. Carefully prepared dry casein is tasteless and odourless, somewhat resembling flour and is easily assimilable. The processes of manufacture of several of these different patent foods are not known with certainty and the methods detailed here merely represent attempts made by the staff to prepare some of them.

For the above foods, casein was precipitated from skimmed milk containing very little fat by curdling with sulphuric acid and purified by squeezing the whey, redissolving the curd in slight excess of ammonia and reprecipitating with slight excess of acetic acid. The purified casein was well washed with water, passed through a screw-press to remove water, dried at 70°C., ground to a powder and bottled.

A substitute for Sanatogen was obtained by dissolving the casein in sodium glycerophosphate, evaporating the viscous mass

to dryness *in vacuo* and reducing the dried mass to powder. The product is soluble in water.

A substitute for Eucasein was prepared by passing ammonia through casein suspended in alcohol and afterwards separating and drying the casein. This ammoniated casein is soluble in water.

A substitute for Plasmon was made by mixing together 80 parts of casein containing about 5 per cent. of fat, 7 parts of sodium bicarbonate and 13 parts of lactose. It is partly soluble in water.

These three casein food products prepared in the laboratory were found to resemble the respective patent foods in colour, solubility and taste.

Nutrose. Groundnut cake is a rich nitrogenous material containing 45 to 50 per cent. of proteids, and is used in the country either as cattle food or as manure. With slight manipulation, it can be converted into a suitable human food and this has already been done in the highly advertised German food Nutrose.[1] Proteids are made up of a number of amino-compounds but the proteids of groundnut cake are deficient in one of them, tryptophane. This is rectified by the addition of dried milk, casein or wheat flour.

Good, well-pressed groundnut cake obtained from the Deputy Director of Agriculture, IV Circle, was ground and 94 parts of the meal mixed with 5 parts of casein and 1 part of sodium bicarbonate, the resulting product being similar to Nutrose. Nutrose is a valuable invalid food, chiefly for diabetic patients of whom there are only too many in India.

If 3 parts of wheat flour are mixed with 1 part of Nutrose, the resulting flour can be made into excellent bread, much superior in nutritive quality and taste to pure wheaten bread.

B. Breakfast and other foods.

Cheese. Good samples of cheese of the Cheddar kind were prepared successfully, notwithstanding climatic difficulties, by two methods—(1) by the addition of rennet, and (2) by sour milk. The

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[1] *The Agricultural Journal of India*, vol. XIII, part II, April, 1918, pp. 351–355.

cheeses were highly appreciated at the exhibition and pronounced to be excellent.

Grape nuts. An attempt was made to reproduce this highly appreciated American food in the following manner. A hundred parts of *cholam* or *ragi* malt were added to 400 parts of wheat flour, and water was added so as to produce a mass of a thick consistency. This was left for four hours so that as much wheat as possible might be digested by the malt. Three hundred parts more of malt were then added and the whole worked into a dough, together with some yeast, kept an hour to ferment and baked in a hot-air oven at 200°C. for about an hour. The baked bread was next cut into thin slices, dried in the draught oven, coarsely pestled in a mortar and sieved to proper grains.

Shredded wheat. Flour milled from well-husked wheat was cooked in steam for two hours. After cooling, a mixture of tartaric acid and sodium bicarbonate, in the proportion of 4 : 6 to 100 of wheat flour, was prepared and the mass was pressed through a die in a screwpress and the issuing shreds collected and rolled gently to resemble the imported article and then baked in the oven until dry and crisp.

Vermicelli and macaroni. Fine wheat rolong was mixed with sufficient water and kneaded into a dough which was then passed through improvised dies in the screwpress. The shreds of vermicelli and the tubular macaroni issuing from the dies were dried in the shade and packed.

Desiccated coconuts. Desiccated coconut is finding increasing application in the preparation of confectionery, sweets, etc., and a number of large factories are run in America for desiccating coconuts. Coconuts are plentiful in this country and the principle of manufacture of desiccated nut is quite simple. Coconuts of medium ripeness were scraped in the household coconut-scraper, spread in thin layers in a draught oven, dried and secured in air-tight bottles, the preserved coconut forming a crisp material. This was much appreciated at the exhibition.

Candied peel. Healthy skins of oranges and lemons, with their inner placenta removed, were boiled in water until they became

soft and the water was drained off. Concentrated thick syrup of cane sugar was prepared and the boiled orange and lemon skins were suspended in the same until they became translucent. The peel was then removed, dried and once again treated with boiling syrup of proper consistency, and stirred until the candied peel nearly set, after which it was stored in bottles.

C. Flours and starches.

Soup flours. Pea flour is the one ordinarily used for making soup for European tastes. As peas are only grown to a small extent in the Presidency, whereas several pulse grains are grown in very large areas throughout the country, an attempt was made to prepare soup flours from these pulses as substitutes for pea flour. Healthy grains of red gram or *dholl* (*Cajanus indicus*), Bengal gram (*Cicer arietinum*) and green gram (*Phaseolus mungo*) were dried in the sun and soaked in water, the lighter grains were scooped out and the soaked grains dried and husked in light stone mills. After winnowing, the clean kernels were ground into flour in a heavy country stone mill, sieved through a fine mesh sieve, dried in the steam oven and put in bottles. The flours have kept well for over six months and have been pronounced, after actual use in cooking on a number of occasions, to be as good as pea flour for making soup.

Starches. Pure white starches are in very great demand in the country, chiefly for textile fabrics. *Cholam*, *ragi* and sweet potatoes were manipulated in the following manner for making starches :—

Cholam and *ragi* grains were separately soaked in 0·3 per cent. caustic soda for 24 hours, washed free from alkali, dried in the sun and ground into flour. The flour was now soaked in 0·15 per cent. caustic soda for another 24 hours, the supernatant liquid was siphoned off and the starches were well washed until free from alkali, and the fine starch granules were separated by sedimentation, dried in the sun and stored.

In the case of sweet potatoes, well-washed tubers were scraped on the surface to remove the brown thin skin, ground in a mortar

to a soft pulp and mixed with water. The starch granules were separated by sedimentation and dried.

All the three starches were fairly pure and analysed as follows :—

Samples	Pure starch	Moisture at 100°C.
Starch from cholam	84·92	8·79
" ragi	84·79	10·63
" sweet potatoes	85·20	9·69

D. Beverages.

Lime juice cordial. The juice of lime fruits was clarified with kaolin, sweetened and sterilized. This refreshing drink has kept well for six months without undergoing fermentation.

Cholam beer. Four thousand grams of malted *cholam* were ground into a meal, mixed with 15 litres of water, to which 5 grams of $CaSO_4$ were added and the whole was maintained at 65° to 70°C. with continuous stirring for three hours, by which time it was found, by testing with iodine, that all the starch had been hydrolysed. The liquid was quickly raised to the boiling point at which it was kept for an hour, 20 grams of tannin and 100 grams of bitter gourd powder having previously been added. To some of the samples 2 oz. of hops were added. The mash liquor was filtered, cooled quickly in running water, diluted to a specific gravity of 1·050 and transferred to glazed pots such as are used in the pot culture house. Baker's yeast was added to a small quantity of the mash liquor to start fermentation and this was added, after six hours, to the liquid, in the pot. The rate of fermentation was tested by specific gravity which gradually went down to 1·025 in 24 hours and then remained stationary. The liquid was poured into beer bottles and corked secure. There was no attempt made at pasteurization for want of suitable apparatus. The beer was tolerably good for a first attempt.

E. Casein and casein products.

Casein. Skim milk (cows' or buffaloes') from a cream separator was used for the preparation of casein. While the coagulation of milk can be effected by several methods, *e.g.*, by the addition of

sulphuric acid, rennet or sour milk, precipitation by sulphuric acid was found most convenient and was effected by mixing 1½ parts by volume of strong sulphuric acid with 7 parts of water and adding the mixture to 1,000 volumes of milk. The precipitated casein was washed and dried and formed the base for the manufacture of a number of products.

Casein paints and distempers. Casein dissolves in solutions of the hydroxides of alkali and alkaline earth metals, being less soluble in the latter. The casein-lime compound, however, has the power of absorbing carbonic acid from the air and becoming insoluble, and it is this property which is utilized in the making of casein paints and distempers. These consist of mixtures of casein and slaked lime with suitable pigments. On the addition of water, the casein and lime combine to form a sticky soluble product holding the pigment in suspension. When spread as a thin layer with a brush on any surface—wall, timber or iron—it absorbs carbonic acid from the air becoming an insoluble durable coating which holds within itself the particles of the pigment. When applied to walls, the paint enters into combination with the underlying plaster and becomes increasingly durable.

The proportions of lime to casein and of the lime-casein to the pigment in the mixture are important. Too little lime makes the product insoluble, especially if exposed during storage, and too much lime induces the paint to come off in flakes. Similarly if too little paint be added, the coating is brittle and liable to flake off, and if too much, the paint will dust off and not stand washing. Again, it is only those pigments which are not affected by lime that are suitable for the manufacture of casein paints. These are, for example :—

whiting, zinc oxide and China clay	.. *for white*
ochre, chrome yellow, etc.	.. *for yellow*
raw and burnt sienna and umber	.. *for brown*
soot and carbon blacks ..	.. *for black*
red lead	.. *for red*
ultramarine	.. *for blue*
green earth, lime green, etc.	.. *for green*

and so on

The recipes for the different paints are slightly different. White paint may be made up of casein 100, slaked lime 100, levigated chalk 800, borax 1 and ultramarine 2 to 3 parts by weight, while the coloured paints may be made from casein 100, slaked lime 100, levigated chalk 400, pigment 400 and borax 1 part. It is important that the ingredients are very finely powdered and thoroughly dried; when stored in tightly closed boxes lined with paper, the mixtures keep indefinitely without losing their properties.

For use, 50 parts of water are added to 100 parts of the powder in a clean vessel and stirred until the mass is homogeneous and free from lumps. The contents are then covered with a thin layer of water and set aside for 45 minutes, after which they are stirred with more water to the consistency of an oil paint. Thus prepared, it should be used without delay as it is liable to set hard in a comparatively short time becoming unfit in twelve hours. Rough surfaces must be painted thinner than smooth ones. As mentioned above, the paint will adhere to any clean surface, such as lime, plaster of Paris, cement, plaster, brick, timber, stone or metal, as well as canvas. It dries quickly with a matte surface and, after 36 to 48 hours, can be washed without fear and will stand the weather. So long as old coatings of lime on walls are removed and the substratum is firm, the casein paints will readily adhere and will not crack or peel off. A glossy paint for indoor use can be produced by spraying the painted surface with a mixture of turpentine and wax and polishing it afterwards.

Casein adhesives. Casein, in solution with caustic alkalis or alkaline salts, has adhesive properties and, as such, has been applied for the preparation of glues and cements which have been placed in the market under various trade names, such as casein-glue, cold glue, caseo-gum, etc. These are suitable for several industrial purposes, especially in wood work, as they are ready for immediate use without previous soaking and heating as with ordinary glue.

For wood, China and glass, 15 to 20 parts of casein are mixed intimately with 1 to 4 parts of borax and sufficient water added with careful stirring, when required for use.

Casein dissolved in a strong solution of borax forms a good, clear adhesive, keeps indefinitely and can replace gum arabic or dextrine. Caustic soda or potash or ammonia could be used instead of borax in making this liquid glue and the addition of a little carbolic acid or thymol prevents any chance of putrefaction.

Casein film.—Casein was tried as a substitute for gelatine in the preparation of photographic paper with good results. Writing paper of good quality was coated with a solution prepared as follows :—

Seventy grams of casein were heated with one litre of water to 50°C., 100 c.c. of a 25 per cent. solution of citric acid added and the mixture stirred until a homogeneous solution was obtained. Twenty grams of glycerine were then added.

The paper which was coated with the above was, after drying in the shade, drawn through a 5 per cent. solution of ammonium chloride to render the casein insoluble, dried and sensitized in the dark room by floating in a 10 per cent. solution of silver nitrate, and again dried in the dark room. Prints were obtained as on ordinary P. O. P., and the operations of toning and fixing were the same as with P. O. P. Several photographs printed on Government lined paper were exhibited.

Shoe and boot polishes. After several trials, the following recipes were found successful :—

Brown polish.—Dissolve 1 part of borax in 20 parts of water, add 5 parts of shellac and warm until dissolved. Add 1½ parts of soap and 2 parts of casein and stir over the water bath until a homogeneous paste is obtained. Now add 2 parts of hard paraffin and incorporate with the paste, and then add gradually, with constant stirring, 30 to 40 parts of turpentine, thinning down with more water as may be found necessary. Finally add enough annato extract to give the required shade of colour.

Black polish.—Dissolve 2 parts of casein in 40 parts of vinegar, add 2 parts of paraffin and heat on the water bath, stirring the while until a pasty mass is obtained. Next add 50 parts of turpentine gradually and stir on the water bath to a uniform paste, adding water as may be necessary, and then incorporate sufficient lamp black into it.

A few drops of nitrobenzene are also added at the end to give an agreeable smell.

F. Miscellaneous.

Lactose or milk sugar. The whey draining from the curd in cheese-making was acidulated with acetic acid and heated on the water bath. The precipitated milk albumen was removed by straining and the evaporation was continued on the water bath until the liquid began to turn brown, after which the concentration was continued *in vacuo* until a syrup was obtained. This was poured in porcelain dishes and allowed to crystallize. When crystallization was complete, the mother liquor was drained off and the crystals were washed with a fine spray of water from which and the mother liquor a second and then a third crop of crystals were similarly obtained. The different crops of crystals were separately redissolved in water, shaken with bone charcoal and filtered. The resulting clear filtrate was concentrated *in vacuo.* In the absence of a centrifugal machine, the final separation of lactose was effected by the addition of alcohol and filtering. From the first crop of crystals a white product was obtained while the other two gave brown coloured crystals of lactose.

Citric acid. Limejuice clarified with kaolin was tested for acidity and the calculated quantity of powdered calcium carbonate added to the boiling juice whereby the calcium citrate was precipitated. The precipitate was washed with boiling water by decantation and the calculated quantity of sulphuric acid (1 of acid diluted with 3 of water) added to the boiling solution, when calcium sulphate was precipitated and the citric acid went into solution. The sulphate was filtered off and the filtrate was evaporated and allowed to crystallize. The crystals were drained from the mother liquor, dissolved again in water, evaporated *in vacuo* and allowed to crystallize. A portion of the crystals was recrystallized by dissolving in water and allowing the water to evaporate slowly at a low temperature.

Tartaric acid. Full grown tamarind pods—not ripe fruits—were crushed in a mortar to a pulp, soaked in water, filtered over

a cloth, boiled with kaolin and filtered under the pump until a clear filtrate was obtained. This was tested for acidity, the calculated quantity of calcium carbonate was added to convert the acid into calcium tartrate and the calculated quantity of sulphuric acid (diluted 1 to 3) then added to the boiling solution, when calcium sulphate was thrown out as a precipitate and filtered off and free tartaric acid left in the filtrate. This was evaporated at a low temperature and allowed to crystallize. The crystals were separated from the mother liquor, redissolved in water and evaporated *in vacuo* and allowed to crystallize.

The two acids, citric and tartaric, prepared as above, are commercial products and cannot be said to be absolutely pure. It is proposed to estimate their exact composition later on.

Papain. Papain is a digestive enzyme acting on the proteids of food and converting them into soluble peptones. In this respect it resembles the pepsin of the gastric juice, but is superior to it in that the latter can act only in an acid medium, while the former can act in acid, alkaline or neutral solutions. The ferment can be easily obtained from the juice of the papaya fruit. Half-ripe papaya fruits, as they stand on the tree, are pricked with a small knife when a milky fluid exudes which soon coagulates to a plastic mass. A fair quantity is thus collected from a number of fruits, the fruits themselves not being spoiled in any way, and then extracted repeatedly with water in which the papain is soluble. The liquid is filtered, evaporated at 50°C. *in vacuo*, and the residue is again dissolved in the smallest quantity of water. The enzyme is now precipitated by the addition of alcohol, filtered, dried at a temperature of 40°C., powdered and stored in bottles.

Conclusion.

The Acting Agricultural Chemist and the staff attended the exhibition wherein the Chemist's stall attracted a great deal of attention from all classes of visitors and a number of samples of the exhibits were distributed.

It was a source of satisfaction to the staff that the Chemist's section was awarded one of the few gold medals presented by the

exhibition and also two Diplomas of Excellence—one for "Food Products" and the other for the work of the section in general. While the work done so far in the laboratory at Coimbatore indicates that great possibilities exist for the manufacture of suitable substitutes for articles now imported out of indigenous produce, it has to be borne in mind that the investigations are far from complete and require more concentrated application than possible in the laboratory of an agricultural chemist, wherein a certain amount of routine work on soils and manures has to be got through every year. The commercial possibilities of the manufacture of the above articles cannot be discussed at this stage until actual trials have been made on a larger scale and the investigations are more complete.

LUCERNE: WHY AN IRRIGATED CROP?

BY

MAJOR J. MATSON,

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I

ALL the writers on lucerne in this country speak of it as a crop which can only be grown by the aid of irrigation. Certainly in the more arid districts it is impossible to grow it without, but we are told that lucerne is successfully grown in America, unirrigated, in districts having a much smaller rainfall than the averages of the United Provinces and much of Eastern Punjab. Further, of all plants it is, or should be, suited to maintain itself alive in periods of drought, in view of its deep-rooted character.

Lucerne is such a valuable fodder that if it can be grown on unirrigated land, a valuable addition to the stock-carrying capacity of the country will be obtained.

II

Accordingly, trials were decided on, and in the autumn of 1915 a plot, measuring 4·6 acres, was selected on the Cawnpore Government Dairy Farm. The soil is a free-working loam of good quality and fairly well drained; it had been trenched in with bazaar sweepings twelve inches deep in about 1904, but in 1915 the only trace of the trenching was a thin black line about ten inches below the surface.

The plot was in grass, cut annually for hay, until 1914, and was then sown to *jowar* (*A. Sorghum*) in the summer, and barley in the winter; in 1915, sown to *jowar* in the summer, and in the winter to oats in which 8 lb. of lucerne seed was mixed.

When the oats were cut, lucerne plants were found thinly dotted about. These seemed healthy and strong, and it was decided to put the plot down to lucerne alone the following autumn. In preparation for this, the land was ploughed five times during the summer, a remarkable thing being that the scattered lucerne plants above mentioned were not killed in the process, although iron ploughs were used. No doubt a few died, but the bulk survived.

During the rains it was frequently cultivated to keep down the weeds, and sown on 29th September at the rate of 18 lb. per acre. A very good take resulted, and the crop grew well. Cutting began on the 28th of December and continued daily for issue to the stock, the rate of cutting being regulated by the pace at which the cut plants grew again, so as to have a continuous issue. This continuous cutting was kept up until the 10th of June, 1917, when the total production amounted to 95,014 lb. green lucerne, or 20,655 lb. per acre. At this time the growth had slackened, though it had not entirely ceased.

After the first monsoon rainfall, another cutting was soon ready and removed from 4th July onwards. The fifth cutting was taken in August, and a sixth was ready early in October, but this was made into hay and is not included in the recorded weights. The actual quantity of green lucerne cut in the twelve months from the date of sowing was 149,130 lb., or 32,421 lb. per acre. It was estimated that, with the October cutting made into hay, which was ready within twelve months from the first *cutting*, the outturn of green lucerne, per acre, was about 39,000 lb.

After each cutting the land was harrowed, the first time very lightly, but increasing in depth after each cutting until at the fourth time the harrows were run two to three inches deep. Seven-tine spring-toothed harrows were used and they kept the land thoroughly clean.

The outturn is less good than it might have been, had not "dodder" appeared in two or three patches in April 1917. We were advised to plough up the whole field, but by *cheeling* (scraping) the patches we were able to get rid of the pest, and then, in the autumn, resowed them.

In the winter and spring of 1917-18 the plant grew practically as well as in the year before, but the measures adopted to eradicate "dodder" reduced the outturn.

In both years the land was given a light dressing of rotted cattle manure, which no doubt helped the plants to some extent; but the important point is the ability of lucerne to establish itself and grow during eight months of practically rainless weather. This it has done now for two years in succession, or three years if the light seeding of 1915 is counted.

The rainfall, outside the monsoon season, has been as follows:—

1st October, 1916, to 1st June, 1917	..	7·04 inches.
1st „ 1917, to 1st „ 1918	..	4·84 „

As the results at Cawnpore, however, were likely to have been aided by the moisture-retaining properties of the old trenching in of bazaar rubbish, it was decided to make a concurrent trial on land having characteristics exceptionally unfavourable to conservation of moisture.

At Karnal a plot was prepared on the edge of a ravine, one of the poorest pieces of soil on the whole farm and exceptionally dry. This was sown in the autumn of 1916 also. The seed germinated well and in April of this year (1918) the plants were still alive and healthy, but the rate of growth has been slow throughout. This plot is in the middle of a grazing field and the cattle have grazed the lucerne with the grass, so no record of outturn has been kept. The only object was to discover if lucerne would remain alive under such conditions and this it has done. It should be stated, however, that the seed in this case was not ordinary Indian lucerne but a variety obtained from the United States called "Montana Dry Land Alfalfa."

Still another trial has been made since at Ambala, a plot of about one acre being sown down in the autumn of 1917. It was cut three times in the following winter and spring, and a fourth crop was kept for seed and harvested in June.

The rainfall at Ambala from 1st October, 1917, to 1st June, 1918, was 10·83 inches.

III

The trials, and our observations during their progress, go to show that unirrigated lucerne can be established successfully on most soils of the Gangetic plain, and that where there is sufficient moisture in the subsoil it will give a highly remunerative outturn throughout the winter and early summer, if the soil is of good quality and well drained.

The outturn will not, however, be quite as much as would be obtained from the same land under irrigation; on the other hand, the percentage of dry matter in the green lucerne is believed to be substantially higher when the plant is grown naturally than when forced by irrigation in a heated atmosphere.

The Cawnpore plant was not very high at any time, but the Ambala specimen was fully up to what would be called a good crop on irrigated land.

The rate of growth between cuttings was clearly and increasingly slower than it would have been under irrigation as the summer advanced, but it was steady and continuous till well on in June at both stations, which is very remarkable.

Another point to notice is that the unirrigated lucerne withstands the monsoon much better than the irrigated, and grows as naturally as at any other time. All the writer's experience of irrigated lucerne is that it gets sickly and practically stops growing in the rains. The reason no doubt is that the irrigated soil is already saturated underneath when the rains come and lucerne cannot withstand the consequent water-logging.

The general result of the trials appears to have a wider application than the military farms.

Two main limitations on the productive capacity of the average cultivated holding are—

(*a*) shortage of cultivating power—in other words, lack of fodder for cattle;

(*b*) lack of soil moisture.

With irrigation allowed on, say, one-third of his total area, the cultivator cannot be expected to devote irrigated land to any but "money" crops.

On the unirrigated land, he can spare a very small area for fodder crops in the *kharif* (monsoon cropping), and he has a certain amount of stalks and straw as by-products both then and in the *rabi* (winter cropping), but the total is far too little.

Advice to grow special fodder crops, such as berseem, for instance, which must be irrigated copiously, naturally finds him unresponsive.

As to *barani* fodder crops, in winter the soil moisture is never sufficient to give a heavy yield, and though a man may be driven to sacrificing a patch of his wheat to tide over a month of scarcity, he is fully alive to its wastefulness and the loss of money he incurs.

Lastly, as we know, the fodders usually produced, *jowar* stalks, *bhusa* and the like, are most innutritious, and if they are to do more than just keep cattle alive must be supplemented by oilcake, etc., at substantial expense.

If therefore we can find a crop which—

(*a*) need not be irrigated,

(*b*) will grow at that season of the year (January to June) when fodder is scarcest,

(*c*) has high food value itself and hence requires little, if any, supplement in the form of concentrates,

(*d*) produces a greater total weight in twelve months than other fodder crops,

(*e*) once sown stands for two or more years, and so saves renewed preparation of the soil and purchase of seed,

a substantial economy must result from its use.

If, in addition, the crop is one which need not displace any other but rather takes the place of the fallow, and this I think can be claimed for lucerne in most cases, there is a clear gain in the total productive capacity of a given area.

It is not suggested that there is anything new about lucerne but it seems possible that we have overlooked its greatest value, namely,

ability to obtain moisture in situations where no other fodder plant can.

The success of the trial at Cawnpore was mainly due to the very thorough and painstaking work of Mr. B. J. Newman, then Manager of the Government Dairy Farm there. The whole idea was as much his as the writer's.

THE TRUE SPHERE OF CENTRAL CO-OPERATIVE BANKS.

BY

N. K. KELKAR,

Governor of the Co-operative Federation, Central Provinces and Berar.

"If the foot shall say Because I am not the hand
"I am not of the body; is it therefore not of the body?"

THE July (1918) issue of the *Agricultural Journal of India* (vol. XIII, pt. III) contains an article from the pen of Mr. R. B. Ewbank on "The True Sphere of Central Co-operative Banks." It is stated that in the last few years there has been a distinct tendency, most marked in the Central Provinces, the United Provinces, and Bihar and Orissa, to make the District Central Bank the pivot of co-operative administration. The arguments are based mainly on theoretical grounds but reference is made to the practice adopted in the United Provinces, and it is implied that the practice adopted in those provinces is typical of the system adopted in the other provinces mentioned. A very copious extract is given from Mr. Willoughby's last (1916-17) Administration Report for the United Provinces. As I shall have occasion to refer to this extract it will bear quoting again at length.

"The system to which we are committed in this province entrusts the finance, supervision and indeed the whole fortune of the movement to the District and Central Banks. These banks are administered by Boards of Directors who are predominately urban and professional. Such bodies are by their constitution ill-adapted to establish the intimate contact required for the fostering and training of such a delicate plant as the young village credit society, or even for its control or finance when adult. The lawyer, banker,

and other professional gentlemen can hardly be expected to find time constantly to visit villages, often distant, and to find out what their staff is doing there. They are inevitably dependent on their paid staff. Now no committee of townsfolk can lend money with advantage or safety to a multitude of individual rustics whom they have never seen and never met and whose credit they cannot gauge through a staff whom they cannot check or control. The attempt is apt to result in the mere substitution of the urban middle class for the village money-lender as the usurer without advantage to either lender or borrower. For with an uncontrolled staff the effective rate of interest really paid tends to be quite as high as the bania's. . . . . Experience has continued to show that too many central societies regard their primaries rather as customers to be bled than as children to be fed."

It is noticeable that if this indictment of the system of control by Central Banks is accepted at its face value it would prove very much more than Mr. Ewbank would accept. For it would indicate not only that Central Banks are incapable of undertaking the audit, training, organization, etc., of primary societies, but also that Central Banks are incapable of performing with safety to their shareholders and with advantage to their primary societies those financial functions which Mr. Ewbank claims to be their sole *raison d'etre.* Indeed no system of Central Banks which "cannot lend money with advantage or safety to individual rustics whom they have never seen and never met and whose credit they cannot gauge through a staff whom they cannot check or control," would be a safe foundation on which to base that organization of central finance which Mr. Ewbank deems to be most desirable. It is worth while therefore to consider whether the system described by Mr. Ewbank is the system which is in force in those other provinces to which he alludes. So far as the Central Provinces are concerned it may be at once stated that the Central Bank is not the pivot of co-operative administration, and that neither control of audit, training, organization or propaganda is entrusted to it. The pivot of co-operative administration in the Central Provinces is the Co-operative

Federation which consists of all co-operative institutions in the Central Provinces voicing their opinion in the Federation Congress by representatives duly elected on democratic principles. Audit is under the control of the Registrar though the staff is partly paid from Federation funds, but the training, organization and propaganda are under the control of the Federation acting through its local representatives.

There is no little confusion in the use of the term Central Bank as applied to the controlling agency and it seems desirable to understand clearly what is meant when reference is made to control by a Central Bank. The Central Bank is a body corporate. It can advance money because as a body corporate it can hold property. Its Directorate may even pass resolutions on questions of policy. But when we speak of control and supervision of primary societies by a Central Bank we are really guilty of a terminological inexactitude. Primary societies can be supervised and controlled only by individuals. It is quite impossible to think of a Central Bank or even the Directorate of the Central Bank inspecting societies. The question that we must decide therefore is whether in the Central Provinces the Co-operative Federation should entrust the fulfilment of its resolutions to individuals, who are also either members or Directors of the Central Bank.

In his article Mr. Ewbank gives a description of the functions of the Central Bank but nowhere lays down either what its constitution is or what it should be. There is a brief reference of a line or two to the representation of primary societies on the Central Bank Directorate but the subject is not pursued. But clearly the constitution of the Central Bank is of the utmost importance in deciding the relation it should bear to its primary societies, and a discussion of this matter is therefore essential to the proper appreciation of the problem. There are three types of Central Banks. The first type sprang into existence when the necessity for affording financial facilities to the primary societies first made itself felt. The function of this type was, as Mr. Ewbank says, to advance loans to primary societies ; it consisted of a small body of individual members having no financial stake in the primary societies who

put up the share capital necessary for the commencement of the business. It is in this sense that the term Central Bank is understood both in Mr. Willoughby's report and Mr. Ewbank's article, and it is against the interference in the affairs of primary societies by the Directors of Central Banks of this type that Mr. Ewbank's warnings are directed. And no doubt what Mr. Ewbank says has very great force in it. For it is obvious that unless the shareholders in a Central Bank are imbued with the true co-operative spirit and unless they are enthusiastic and their higher ideals are aroused, there is a very great danger of interference with the primary societies in the interest of what is commonly known as dividend-hunting. We have had our experience of this type of Central Bank in the Central Provinces, but our experience has been more fortunate than appears to have been the case of the United Provinces. Our Directorates were originally formed of Malguzars, richer agriculturists, pleaders and a small sprinkling of money-lenders. But we have always been able to secure on the Directorate men whose enthusiasm has been aroused and whose work has been disinterested and truly co-operative, and it is to such men that in the commencement the Co-operative Federation entrusted the execution of the policy laid down by it. Our lawyers have found time to visit village societies; in fact in several Central Banks the prominent pleaders have spent every civil court holiday throughout the year on tours of this sort. Our Secretaries of Central Banks have made a point of seeing and discussing village affairs with the societies when they come to Central Banks to take their loans, and even in the first stage of Central Banks it would be incorrect to say that the Board of Directors had been out of touch with primary societies or out of sympathy with their demands and requirements. At the same time so long as there is a possibility of a clash of interests between the individual shareholders of the Central Bank and the primary societies, it cannot be held that the organization is truly co-operative, and it is for this reason that we have advanced in the Central Provinces to the second form of constitution of Central Banks.

In the second stage the societies, having by this time acquired sufficient reserve funds or accumulated profits, are in a position to

take up shares in Central Banks. Inasmuch as the number of societies in these provinces is larger than the individual shareholders the societies have acquired a controlling interest in the banks and the majority of the Directors of the Central Bank are elected from amongst their own members by the primary societies and Circle Unions affiliated to the bank. The primary societies have thus a controlling voice in all questions of policy in the bank (subject of course to the resolutions not conflicting with the resolutions of the Co-operative Federation by which so long as they continue members of the Federation all are bound), and any attempt at selfish interference in the affairs of the societies in the interests of the individual shareholders of the bank would be very quickly suppressed. For it is not true, as some people believe, that the agriculturists are dumb, voiceless individuals. On the contrary, when their interests are concerned they are quick with their suggestions and slow to accept interference even by the more educated shareholders. The third type of Central Banks I need not discuss. It is an ideal to which we hope to attain, when the primary societies' reserves are sufficient to take over the shares now held by individual shareholders both in Central and Provincial Banks. The accomplishment of this will take time, but when we shall have accomplished this we shall have the co-operative movement owned and controlled entirely by primary societies and their representatives.

It will now be apparent that the duties and functions which can be entrusted to the Directors of Central Banks must vary at the different stages of the movement. The functions of a Central Bank, *qua* Bank, are, in Mr. Ewbank's words, to say "yes" or "no" to loan applications, and in so far as a Central Bank approximates in type to an ordinary joint stock bank, in so far as the first consideration is the interest of the shareholders and not the interest of the societies, to that extent it is unsafe to allow the Directors of the Central Bank any part in the education or general supervision of the movement. But when the Central Bank is not merely a bank but a co-operative institution, when the interests of the Central Bank and its constituent societies are one, it is desirable, indeed it is necessary, that the members and Directors of the Central

Bank should take their proper place in the co-operative sphere, and it would be as illogical to exclude such Directors from supervising or training the constituent societies, either themselves or through the Federation staff placed under their control by the Federation, as it would be to expect the members of the *panchayat* (managing council) of the primary society to abstain from supervising or training the individual members.

Accepting the principle that the ideal to be aimed at is a system of societies and banks owned by the agriculturists themselves, that is to say, owned by the primary societies—and few would deny that this is the ideal at which co-operation aims—it is difficult to see how as the movement progresses it is possible to avoid entrusting training, organization and propaganda work to Directors and members of Central Banks. Mr. Ewbank states that in Bombay training and supervision are entrusted to guaranteeing Unions and in places where there are no Unions to local co-operators and chairmen of first rate societies. In the Central Provinces also training and supervision are entrusted to guaranteeing Unions and to representatives of primary societies sitting on Circle Union Committees. But the difference is that Circle Unions are members of the Central Bank, and chairmen of first rate societies and local co-operators of any eminence are without exception either members or Directors of the Central Bank. In fact as agriculturists accumulate profits and become themselves their own capitalists, it is inevitable that those individual shareholders in the Central Bank not otherwise connected with co-operation and out of sympathy with it should be gradually replaced by representatives of the primary societies; as this change occurs it becomes impossible and undesirable to disassociate the members of the Central Bank from controlling and regulating the primary societies, for those members are merely representatives of the societies and their control is not an outside control by persons whose interests are conflicting with those of the movement but inside control by the properly educated and more enlightened co-operators themselves.

Now, as regards the control of staff, we have always made a distinction between the banking staff as such which is paid for out

of the profits of the Central Banks and engaged in verifying the material assets owned by borrowing societies and looking after their trustworthiness in the interests of the shareholders, and the Federation staff which is paid for not by the Central Banks but by the Federation out of its own funds and which in addition to training and sometimes organizing societies visits each society at stated intervals and writes up its accounts. I should explain here that owing to the backwardness of education in the Central Provinces very few out of the several thousand societies comprise members sufficiently literate to write their own accounts. The primary societies have always been taught to regard the members of this travelling Federation staff as their servants and not the agents of the Central Banks. It has been impressed on them that the pay of this staff is provided by their own contributions to the Federation, and the few irregularities which have occurred on the part of the staff had been brought to light with surprising rapidity by the primary societies. The local control of this staff is entrusted frequently, though not necessarily, to the Honorary Secretary of the Central Bank, and this appears to have given rise to the idea that the whole control of primary societies is centred in the bank. But it should be remembered that the control of this staff is entrusted by the Governor of the Federation to the Honorary Secretary of the bank as the agent and local representative of the Federation. It is not essential that it should be so entrusted, and from time to time in some Central Banks members of the Federation staff have been placed to work under the chairmen of local Unions and well-known *sirpanches* of primary societies, and in the event of any abuse of the kind indicated by Mr. Willoughby in his report it would be open to the Governor of the Federation to entrust the supervision of the local Federation staff to any other co-operator or several other co-operators as agents of the Federation.

Mr. Ewbank quotes at length the analogy which Mr. Crosthwaite draws[1] between the units of the co-operative system and the units of the Army, and concludes, "the gospel of centralization

[1] "Co-operative Studies and the Central Provinces System," part III, chapter I.

could scarcely be preached in a more unequivocal language." It is always dangerous to extract quotations without reference to their context, and a very cursory perusal of the chapter referred to would convince the reader that the author's intention was not to preach centralization but to combat excessive individualism and to show that discipline is implied in co-operation whether it be co-operation of individuals or of societies. The opening words of the chapter read :

"The main principle upon which the Central Provinces system of co-operation is based is that, apart from the necessary control by Government of a movement deeply affecting public interests, nothing must be done for co-operators (*i*) which they ought to do for themselves, (*ii*) which they are competent to do for themselves"; and again later,[1] "Quite a common idea among the educated pioneers of the movement is that, though Central Banks can be managed by them, the village societies cannot and need not be managed by their members. That is to say, self-government may be very good for a Central Bank but is very bad for the societies working under that bank. It is difficult to understand the reasoning which permits sincere and thinking men to fall into an error of this kind. Unless the societies are instructed and patiently trained, they will never know what self-help is, and unless they are left to apply what has been taught them, they will never know what self-help means. A Central Bank which does not train its societies to independence is not doing its duty and is working on lines which are not only wrong but injurious to the country."

Surely it is not centralization but decentralization to the widest extent compatible with co-operation which is here preached. But co-operation implies discipline and self-sacrifice ; this is clear enough in the village society, and it would appear illogical and inconsistent to emphasize the importance of discipline and self-sacrifice among the individual members of a primary society and to deny their necessity when co-operation advances a step further and becomes co-operation between societies instead of between individuals.

[1] *Ibid.*, paragraph 253.

The truth is, the Central Provinces system is not a centralized but an unified system. The whole co-operative movement is regarded as a single body in which each member performs its proper function. Issues which can be decided by the primary societies cannot be decided by the individual members of such societies; so also while some functions must be entrusted to the Directors and members of the Central Bank as representing the societies in a district, other functions must be entrusted to the Co-operative Federation as representing the whole movement. We recognize that co-operation does not begin and end in the village. There must be co-operation between societies working upwards from the Circle Unions to the Central Bank and Provincial Bank, and when the time comes, the All-India Federal Bank, and each part of the co-operative organization should perform those functions for which it is best fitted. One of the illustrations which Mr. Ewbank gives of matters in which the liberty of primary societies is unduly fettered is the investment of reserve fund and the purchase of shares by primary societies in the Central or Provincial Banks. Why, he asks, should the societies be compelled either to take shares in the Central Banks or to invest the reserve fund outside their own societies? We should reply that the members of primary societies are incapable of investing their reserve funds in any other way than in their own working capital because they are not sufficiently advanced to appreciate the matters at issue. It will of course not be disputed that an agricultural society, even though extremely advanced, could not be expected to appreciate the rival merits of the English War Loan and the Indian War Loan in the present state of exchange; and any investment of this sort as a matter of course would have to be done for them. But leaving minor points like this on one side, we would maintain that inasmuch as the reserve fund represents in the Central Provinces the whole, and in other provinces a very large portion, of the profits of primary societies, the whole future of the movement depends on its proper utilization. If the primary societies, that is to say the agricultural classes, are ever to own their own Central Banks and their own Provincial Banks, then the investment of the reserve fund must at present be left in the hands of the more

enlightened people in whom the primary societies by electing them as their representatives have displayed their confidence. If an All-India Federal Bank is ever to be more than a dream, it is to the accumulated reserve fund of primary societies that we must look for the capital necessary to establish such a Federal Bank. Further, if the agricultural classes are ever to advance, if they are ever to learn to manage their own affairs, and by their chosen delegates the affairs of Central Banks, Provincial Banks, and the All-India Federal Bank if established, it is to the educative influence of representative institutions as displayed in the Co-operative Federation that we must look for the necessary stimulus to raise them from the apathy and indifference in which they are now sunk.

MANURES IN THEIR RELATION TO SOILS AND CROP PRODUCTION IN THE CENTRAL PROVINCES.*

BY

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THE four principal soils of the Central Provinces are the alluvial soils of the Nerbudda valley which corresponds to the wheat tract, the black cotton or trap soil of the cotton tract, and the lateritic and metamorphic soils of the rice tract. Without manure and irrigation most of the area under these soils has reached the stage of maximum impoverishment and now yields approximately 600 lb. of wheat, 300 lb. of *kapas* (unginned cotton), and 900 lb. of paddy per acre, respectively, without irrigation. Given irrigation without manure, the crop outturns are increased by approximately 100 lb. of wheat, 30 lb. of *kapas*, and 550 lb. of rice per acre, respectively.

If cattle manure were available in sufficient quantities at present prices, there would be little chance of finding any other manure which could compete with it. But in the Central Provinces much of the cattle-dung is used as fuel, and in most districts, even that part of it which in the rainy season cannot be dried as fuel is left exposed in an open heap together with the ashes of dung which has served its purpose as a fuel. Ordinary village manure made in this way contains on an average 0·46 per cent. of nitrogen, while cattle manure properly stored on Government farms in the provinces contains 0·68 per cent. Nitrogen which is the one constituent

* A paper read at the Fifth Indian Science Congress, Lahore, January, 1918.

in which our soils are so deficient happens to be the particular one which is wasted to the greatest extent by the cultivator, for in the process of burning, over 97 per cent. of the nitrogen of cattle-dung is dissipated. It has been proved, too, that the rain of tropical countries in general does not supply the soil with a greater amount of nitrogen than the rain of temperate climates, the average total for tropical countries being only 3·54″ per acre annually. While the quality of cattle manure is very poor, the quantity available every year is very small, being only about one cartload per acre of crop grown. If every field were to be manured at intervals of 8 years, the quantity of manure available per acre would only be about 64 mds., or approximately 8 cartloads. But a very considerable part of the total quantity of cattle manure used is, as a matter of fact, applied not to the fields in which our staple crops are grown but to cane and garden lands. This unequal distribution of the supply still further reduces the quantity available for open field cultivation. How to meet this deficiency in the supply is one of the problems to which the Agricultural Department has been giving serious attention for the last 12 years, and a large programme of manurial experiments has been carried out on the Government experimental farms with the view of finding manures which can be used to supplement the very inadequate supply of cattle-dung at present available. In describing the results obtained I shall confine my remarks to the rice and cotton tracts with which I am better acquainted.

The application of enough cattle-dung to supply 10 lb. of nitrogen per acre has added from Rs. 10 to Rs. 15 to the net acreage profit on rice cultivation. The same amount of nitrogen applied as poudrette has increased the net profit by from Rs. 15 to Rs. 20, while the same quantity applied as night-soil has increased it by from Rs. 20 to Rs. 30 per acre. The application of calcium cyanamide and of bonemeal separately and of bonemeal in combination with saltpetre has resulted in a dead loss. Bonemeal combined with sulphate of ammonia has generally given a small profit as have also dried leaves and tank silt. Castor cake has given a small net profit in some series only: in others its application resulted in a loss.

The only manures which have consistently given large acreage profits are cattle manure, night-soil, and poudrette. The supply of night-soil and poudrette is so small and the difficulty of getting sweepers to apply them so great that they are only of secondary importance as an economic factor in crop production. It therefore becomes evident that of the manures available in any quantity cattle-dung is the only one which really counts. The use of green manures therefore suggested itself as being the most likely method of finding a substitute for cattle-dung. Owing to the peculiar nature of our rainfall which extends from the middle of June to the end of September, a period which coincides with the period of greatest growth of the rice plant, the only crop which is at all suitable as a green manure for rice is a fast growing one which, when sown in the middle of June, will be ready for application by the end of July at which time the seedlings are being transplanted. Sann-hemp (*Crotalaria juncea*) has been found to be a sufficiently fast grower, but when grown in the bunded rice plots its growth is checked so much by the heavy rainfall of the early monsoon that it is found impossible to raise any quantity of it in time for ploughing in for the succeeding rice crop. *Dhaincha* (*Sesbania aculeata*) thrives much better under the same conditions, but is too slow a grower. The difficulty in producing a sufficient bulk of *sann* has been finally got over by growing it in the open fields reserved for *rabi* (winter) crops. In one acre of *rabi* land about 300 mds. of *sann* per acre can be grown in time for ploughing in for rice. This suffices as a green manure for 3 acres of rice. The analysis of this green sann-hemp showed that it contains 0·57 per cent. of nitrogen, so that it is about equal in manurial value to cattle-dung bulk for bulk. Over the greater part of the rice tract of the Central Provinces, the *rabi* or winter crop area lying fallow during the rains and therefore available for the production of sann-hemp as a green manure for rice, is almost equal to the area under rice. It is possible therefore to raise much more green manure than is needed for rice and without reducing the area under *rabi* crops such as wheat, gram, linseed, etc. The practice will, we believe, be a positive advantage, as far as *rabi* crops are concerned, as the standing crop of *sann* helps to check the

growth of weeds and to reduce to a minimum the damage which would otherwise be done to the fields left fallow during the monsoon. The manurial value of the roots of the *sann* for the *rabi* crop should also be appreciable. Experiments to test it have been started. This new method by which fallow land is utilized for the production of green manure for rice, is applicable to over 4 million acres of rice land in the Central Provinces, and I anticipate that it will largely solve the manurial problem as far as the rice tract is concerned. It was tried by landowners in over 40 villages last year. The average increase obtained from the fields manured in this way amounted to over 600 lb. of paddy per acre, worth approximately Rs. 15. The cost of raising this green manure was about Rs. 3 per acre manured, leaving a net profit of Rs. 12 per acre.

The use of cake as a cane manure was demonstrated by the Department for the first time six years ago. This manure, though not previously in use anywhere in the provinces, has now caught on, and is being used in larger quantities every year by cane-growers. Sann-hemp, applied at the rate of 10 tons per acre to the sandy loams in which cane is generally grown in the rice tract, has, when supplemented by a dressing of 15 mds. of cake, given yields of about 20 tons of cane per acre, which, when converted into *gur*, is worth approximately Rs. 330. The cost of the manure applied in this case is only Rs. 33. The average outturn of cane for the provinces, manured with cattle-dung, is only 11 tons, which is worth approximately Rs. 184. By this new method of manuring the net profit on cane cultivation can be increased by about Rs. 146 per acre.

In the cotton tract the value of manure is more highly appreciated than in other parts of the provinces. Cotton pays better than rice or wheat, and cultivators have come to realize the economic value of cattle manure. The price per cartload is R. 1 as against 8 annas for the greater part of the rice tract. But in the cotton tract, too, much valuable manure is wasted. No attempt is made to conserve the urine which is so rich in nitrogen. To meet this formidable obstacle to good cultivation, the dry-earth system of conserving urine has been demonstrated in this tract. Experiments

carried out with urine earth on the Government farms have shown that, in the year of application to *jowar* (*A. Sorghum*) and cotton fields, the urine of a bullock for any definite period of time, is equal in manurial value to its solid excreta for the same time. By this system of conserving the urine, dry earth to a depth of 6″ is spread in the stalls. This earth is removed to the manure pit once a month, and fresh earth is put into its place which, in turn, absorbs the liquid portion of the animal's excreta for the succeeding month. By adopting this system of conserving cattle urine the intrinsic value of the manurial supply of a village can be doubled at a very small cost.

Cotton cultivation on well manured land is so profitable at the prices which have prevailed of recent years that it would pay the cultivator to manure his cotton, even if cattle manure were three times as expensive as it is at present. The supply, however, is so very inadequate that there is none available for sale in the villages. Green-manuring is not a feasible proposition in this tract as it would have to be grown at the expense of cotton and *jowar*, for the manuring of *rabi* crops of which the area is comparatively small. To meet the full requirements of the cotton tract, therefore, it will be necessary to fall back on manures not at present in use, and this we hope to be able to do by the use of nitrate of soda on a large scale, and by the utilization of such quantities of manurial cakes as are manufactured locally. If it were possible to offer nitrate of soda for sale at about Rs. 10 per cwt., the demand for it would, I believe, be large. On the strength of the results obtained from the trials of nitrate of soda on the Akola farm, the Commissioner of Berar put up a proposal this year to the effect that about a lakh of rupees worth of this artificial should be offered for sale to cotton-growers in his division which constitutes the greater portion of the cotton tract. The price, however, had risen so enormously owing to the war that it was considered inadvisable to make large purchases at the present time. There is little doubt but that it would pay handsomely to apply nitrate costing Rs. 10 per cwt. as a topdressing to cotton at the rate of 60 lb. per acre. This quick-acting manure is specially suitable for short-season cottons.

In conclusion, I should like to lay stress on the fact that though in the Central Provinces and in other parts of India much has already been done by the Department of Agriculture to solve the problem of economic manuring, a poor cultivator will not be in a position to reap the full benefit from the results of these researches until we make it easy for him to obtain these manures. We require, in short, an efficient organization which will provide both for the supply of manures and for the financing of purchasers who wish to buy them. This may possibly be done later on a large scale through co-operative societies. To pave the way for co-operative societies it may be necessary to finance the cultivator direct to start with. It should be quite feasible for Government to provide a definite sum to be given each year as *takavi* for the extension of agricultural improvements recommended by the Department of Agriculture. This has, as a matter of fact, been done in the Central Provinces, and it is a policy which is well worth the consideration of any provinces which may not yet have adopted it.

NOTES ON THE HYDROCYANIC ACID CONTENT OF JOWAR (*ANDROPOGON SORGHUM*).

BY

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It has long been known that a cyanogenetic glucoside, called dhurrin, is present in *jowar* in certain stages of its growth. This glucoside is not poisonous by itself, but it breaks up, in contact with an enzyme which is present in the plant tissues, into several compounds, one of which is hydrocyanic acid. It is on account of the formation of this latter substance that *jowar* acts as a poison, and cases of poisoning of cattle by the plant are not of infrequent occurrence. In 1915 a number of cattle deaths took place near Sabour. That year there was a particularly long period of dry weather immediately after the crops were planted, a condition which does not happen every year. It was then suggested that, owing to the insufficiency of moisture in the soil, the plants were stunted and did not grow properly, and that, in consequence, there was an excessive development of the cyanogenetic glucoside which yielded the poison. It was then proposed to investigate the circumstances which help the accumulation of the poison-producing compound in the *jowar* plants.

Accordingly, at the suggestion of Mr. Somers Taylor, Agricultural Chemist to the Government of Bihar and Orissa, a trial was made to find out the effects of different times of planting, and also of water-logging, on the formation of the glucoside in *jowar*. The idea was to sow some of the plots very early, well in advance of the usual time, so as to obtain, as far as possible, a condition similar to that of 1915, *viz.*, a period of comparatively dry weather in the

growing period, and also to sow some of the plots very late, after the rains have well set in, so as to have always an excessive quantity of moisture in the soil. Unfortunately the rains were late in coming, so late as to make very early planting impossible, and there was no abatement of rains once they had set in, so that the first condition of comparative drought was not obtained. On the other hand, owing to heavy and frequent rain, all the plots were water-logged, and the plants, weak and stunted, even after six weeks, showed no tendency to grow up at all. A very small quantity of hydrocyanic acid was all that was obtained—a fact which suggests that water-logging is unfavourable to the formation of cyanogenetic compounds in *jowar*. There was no case of cattle-poisoning* that year by *jowar*. The following table illustrates the result :—

TABLE I.

Plot No. I E. P.

Age of plants	Date of analysis	HCN%
Over 4 weeks ...	6th July 1916	0·000912
5 ,, ..	9th ,, ,,	0·000456
Over 5 ,, ...	12th ,, ,,	0·000500
Over 6 ,, ...	18th ,, ,,	Traces
	Plot No. II E. P.	
4 weeks ...	6th July	0·000608
About 5 ,, ...	9th ,,	0·000512
Over 5 ,, ...	12th ,,	0·000456
Over 6 ,, ..	18th ,,	Traces

The experiment was repeated in 1917. The first of the plots were sown on 12th May. Before that there were only two inches of rain distributed over six days, and there was no rain after until the 27th May. But just on the night previous to the day when the first samples were collected, there was a shower (½ inch) of rain, so that the actual condition of the plants during the period of drought was not exactly known. An excessive quantity of prussic acid was found, which, however, fell down to less than half in about three weeks, during which period there were occasional showers.

* A few cattle deaths reported from Bettiah were suspected to be due to the cattle eating a weed, *Andropogon halepensis*, which is also, like *jowar*, capable of yielding HCN. But at the time the weeds were collected and received at Sabour for examination, no HCN was obtained from them.

The results were not even on all the plots.

TABLE II.

Date of analysis	Plot I E. P.	Plot II E. P.	Plot III E. P.
	HCN%	HCN%	HCN%
28th May ...	......*	0·196*	......*
5th June .	......*	0·099*	......*
8th „ ...	0·121	0·092	0·124
12th „ ..	0·060	0·045	0·057
19th „ ...	0·075	0·025	0·021
26th „ ...	0·041	0·004	0·013
3rd July ...	0·032	0·009	0·008
10th „ ...	0·019	0·003	0·009
17th „ ...	0·024	......	......
31st „ ...	0·012	......	......
13th August ...	Traces	......	......

The poisonous properties most persisted in the plot E. P. I. This plot was, however, marked by a more vigorous growth, as is evident from the greater average weight of the plants, and also by the greener and more healthy appearance of the leaves (Table III).

TABLE III.

Average weight and height of a plant.

Date	Plot I E. P.		Plot II E. P.		Plot III E. P.	
	Weight	Height	Weight	Height	Weight	Height
3rd July ...	122 gms.	150 cm.	108 gms.	170 cm.	112 gms.	180 cm.
10th „ ...	338 „	200 „	293 „	200 „	245 „	200 „
17th „ ..	367 „	250 „	......	......	267 „	200 „

Here is a result which is contrary to all expectations, for it has long been believed that a healthy and vigorously growing *jowar* plant yields much less poison than its weak and stunted brother. This result received a remarkable confirmation from the observations of some later plants. In the case of thickly sown plants, what always happens is that a good many receive a much later start and lag behind, in the matter of growth, their stronger and older brothers. This may be due to malnutrition or to the secretion of injurious products by the older plants, but that strong and healthy plants contain more prussic acid can be seen from the following table :—

* As the plants were then very small, the samples collected from the three plots were analysed together.

Table IV.

Plot IV (Usual time).

Date of analysis	Average weight	Average height	HCN%
16th July, 1917 ...	17 gms. 81 ,,	80 cm. 127 ,,	0·0080 0·0151
23rd July, 1917 ...	22 ,, 143 ,,	100 ,, 170 ,,	0·0090 0·0153
30th July, 1917 ...	26 ,, 191 ,,	96 ,, 200 ,,	0·0075 0·0047
	Plot V (Usual time).		
16th July, 1917 ...	17 gms. 122 ,,	75 cm. 120 ,,	0·0076 0·0190
23rd July, 1917 ...	32 ,, 117 ,,	85 ,, 160 ,,	0·0053 0·0065
30th July, 1917 ...	12 ,, 244 ,,	95 ,, 196 ,,	0·0128 0·0110
6th August, 1917 ...	26 ,, 547 ,,	119 ,, 216 ,,	0·0045 Traces

The time of planting does not appear to have any effect on the formation of dhurrin. With the three sets of plots sown at different times, and nearly at a month's interval between one and the next, there was no difference between the first and the second set, both as regards the maximum yield of the poison or its rate of diminution as the plants grew up, but the third only showed half the maximum quantity of the poison, though the rate of diminution of the poison was very much the same. The low maximum of the third set which was planted last at a time (8th July) when there was an excessive amount of moisture* in the fields, and when there were heavy downpours of rain previously and subsequently to the sowing, may be due to an abundance of soil moisture.

The following table is given for comparison :—

Table V.

Plot III L. P.			Plot II E. P.			Plot IV U. P.		
Date of sowing	Date of analysis	HCN %	Date of sowing	Date of analysis	HCN %	Date of sowing	Date of analysis	HCN%
8-7-17 ...	25-7-17	0·0452	12-5-17	23-5-17	0·1960	7-6-17	25-6-17	0·0910
	1-8-17	0·0381		5-6-17	0·0990		2-7-17	0·0904
	9-8-17	0·0279		8-6-17	0·0920		9-7-17	0·0211
Planted very late.	15-8-17	0·0285	Planted very early.	12-6-17	0·0450	Planted at the usual time.	16-7-17	0·0079
	21-8-17	0·0173		19-6-17	0·0250		23-7-17	0·0153
	29-8-17	0·0148		26-6-17	0·0042		30-7-17	0·0091
	5-9-17	0·0050		3-7-17	0·0093		6-8-17	0·0075
				10-7-17	0·0031		14-8-17	
				17-7-17	Traces			Traces

* See Table of Rainfall (Table VII).

It is therefore obvious that while the time of planting by itself has little or no connection with the formation of the glucoside, yet a crop planted late has a much better chance of producing smaller quantities of the poison on account of the abundant moisture which is generally found in the soil in such a time.

Dhurrin occurs principally in the leaves and young shoots. There is a very much smaller quantity of it in the stalk, from the time the plant grows to an appreciable height, *viz.*, about 100 cm. The percentage of total nitrogen in the leaves is also proportionally greater than in the stalks, evidently owing to an accumulation of non-protein nitrogenous matter (Table VI). In ratooned *jowar*, when young shoots spring up from old stalk, the *jowar* is considered to be highly poisonous, although the parent stock at the time might contain practically no glucoside. This occurrence of the glucoside, especially in the places of active metabolism, is suggestive of some compounds being formed and fixed by the plant in such forms.

The exact part played by it in plant economy can only be known when the factors influencing its formation are known with certainty. The cyanogen may be an intermediate product in proteid formation, or it may act as a harmone, which is the general name of a variety of substances which are able to penetrate the walls of plant cells, thereby disturbing the equilibrium within the cell and producing changes which involve alterations of the concentration and the liberation of hydrolytic enzymes. If the former view be correct, it would signify that strong and healthy plants, which form more proteids than weaklings, would gather more glucoside at a time when proteid formation is very active. It is very suggestive that the total nitrogen percentage in a plant shows more or less a steady diminution as the plants grow up, but not at such a rapid rate as the hydrocyanic acid. No reliable evidence has been obtained that weak and sickly plants can produce, as a rule, more hydrocyanic acid ; in fact, evidence, as far as has been obtained, points to the contrary. Let us examine the factors which have so far come to our knowledge as likely to bear on the production or otherwise of the glucoside. In the first place, an abundance of moisture in the

soil is always associated with a low percentage of dhurrin, and sickly plants growing in water-logged soils contain only a minute quantity. The contrary is also probably true, in spite of scanty experimental evidence, *viz.*, a deficiency of moisture in the soil or a dry period is conducive to excessive glucoside production in *jowar*. There is no doubt that the experience of the general body of cultivators is in favour of this view, and here and there facts have been brought out suggestive of it, but apart from that, no further experiments appear to have been carried out which would fully bear out the cultivators' views. Secondly, the rate of growth has long been thought to have some correlation to the poison-producing power in the plant, the most poisonous plants being those which make a very unfavourable growth. It has been shown that this is not necessarily true, and that in the case of strong and weak plants growing side by side in the same field, it is not the weak plants alone which always yield the greater amount of hydrocyanic acid. Thirdly, there is a far greater amount of nitrogen accumulation in the leaves than in the stalks. The appearance of this greater quantity of nitrogenous substances exactly in the parts where the greatest quantity of hydrocyanic acid occurs, is an indication that the production of the glucoside is in some way correlated with the production of the nitrogenous matter, and lends support to the theory that prussic acid is an intermediate product in proteid formation, and that its occurrence is an evidence of nitrogen assimilation. Water-logging presents a very unfavourable condition for nitrogen assimilation, as it prevents bacterial activity and stops nitrification. This accounts for the production of merely traces of hydrocyanic acid in the crops of 1916. In warm dry weather, before the rains have actually fully set in (according to Leather's drain-gauge experiments at Pusa[1]), the seat of nitrification is much nearer the surface and therefore presents a more favourable condition for nitrogen assimilation by the young plants whose roots at the time do not penetrate deep enough. With the coming in of the rains the principal seat of bacterial activity

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[1] *Memoirs of the Department of Agriculture in India, Chemical Series*, vol. II, no. 2.

moves downwards, and there is a likely loss of soluble nitrates by overflooding and drainage, and partly on this account and partly on account of the very rapid rate of growth, when the glucoside formed is rapidly utilized to furnish higher and more complex compounds, there is less and less hydrocyanic acid obtained as the plant grows up until it is fully grown. Thus the accumulation of the acid in the young plant in normal years and its diminution with the age and growth of the plants receive an explanation. But in years of scanty rainfall, as the vital activities of the plant are retarded on account of lack of moisture, the utilization of the cyanogenetic compounds will probably take place much more slowly, and the plant will indicate a quantity of the poison which it cannot at once get rid of. These are, however, still suggestions and have to be substantiated in the light of further experiments.

It would therefore appear that the weather is mainly responsible for the development of the poisonous elements in the *jowar*. The soil is only of minor importance and is accountable only so far as it can hold up nitrogenous food materials to the plant. Brunich in Queensland found that the poisonous properties of *jowar* increased with improved fertility, and Treub[1] stated that nitrates exert a direct influence on the production of hydrocyanic acid. Against this there are American results[2] that in a rich soil, however well provided with plant food, an addition of nitrogenous fertilizers has been found to exert no appreciable effect, while in a poor soil there appears to be an increase, though to a slight extent. The soil, therefore, though it may help in the production of the glucoside, is only a minor factor, and the weather, notably rainfall, is the factor of greater importance.

It is proposed to continue the study still further.

[1] Treub, M. *Ann. Jard. Bot. Buitenzorg*, 2, ser. 4, pt. 2, pp. 86-142 (noted in *Expt. Station Record*, vol. XVII, p. 347).

[2] *Journal of Agricultural Research*, vol. IV, no. 2.

TABLE VI.

Showing the percentages of hydrocyanic acid and of nitrogen in different parts of jowar *plants at different stages of growth.*

Plot No.	Date	HCN%	N%	HCN% in leaves	N% in leaves	HCN% in stalk	N% in stalk
E. P. I ...	8-6-17	0·12100	0·5060				
	12-6-17	0·06000	0·6260				
	26-6-17	......	......	0·0128	0·500	0·00750	0·201
	3-7-17	0·03240	0·5130	0·0565	0·677	0·01660	0·404
	10-7-17	0·01870	0·4580	0·0452	0·754	0·00603	0·316
E. P. II ...	8-6-17	0·09200	0·4030				
	12-6-17	0·04500	0·4920				
	19-6-17	0·02500	0·3730	0·0230	0·495	0·01500	0·161
	26-6-17	0·00420	0·3880	0·0075	0·547	0·00380	0·297
	3-7-17	0·00930	0·3580	0·0143	0·630	0·00600	0·352
E. P. III ...	8-6-17	0·12400	0·4200				
	12-6-17	0·05700	0·4750				
	19-6-17	0·02100	0·3260	0·0300	0·496	0·05100	0·215
	26-7-17	0·01260	0·4460	0·0136	0·547	0·01130	0·351
	3-7-17	....	......	......	... ..	0·00750	0·291
U. P. I ...	25-6-17	0·09100	0·4650				
	2-6-17	0·09040	0·6040				
	9-7-17	0·02110	0·4820				
	16-7-17	0·00792	0·6640				
Stunted plant) ...	23-7-17	0·00905	0·3504				
(Strong plant) ...	23-7-17	0·01530	......	0·0317	0·299	0·00603	0·082
(Stunted plant) ...	30-7-17	0·00754	0·2030				
Do. ...	6-8-17	0·00151	0·2940				
U. P. V ...	25-6-17	0·82900	0·4800				
	2-7-17	0·82600	0·6160				
	9-7-17	0·21600	0·5060				
	16-7-17	0·00758	0·4970				
	23-7-17	0·00650	......	0·0098	0·208	0·00452	0·068
(Stunted) ...	30-7-17	0·01280	0·2080				
	6-8-17	0·00452	0·2740				

TABLE VII.

Table of rainfall in inches, May to August 1917, *recorded in the Sabour Agricultural Station.*

Day of the month	May	June	July	August
1	......	1·95	0·07	2·47
2	......	......	......	3·33
3	......	......	0·70	0·45
4	0·43	......	3·45	0·20
5	0·03	......	......	......
6	0·85	......	......	......
7	0·05	......	......	......
8	......	......	0·07	0·12
9	0·03	0·40	......	0·45
10	......	......	......	0·48
11	0·72	......	0·31	1·53
12	......	......	......	1·00
13	......	......	1·40	0·04
14	......	0·46	......	0·14
15	......	0·58	......	0·04
16	......	......	......	......
17	......	......	......	......
18	......	0·17	0·16	0·96
19	......	......	0·15	......
20	......	......	......	......
21	......	0·32	......	0·04
22	......	0·15	......	......
23	......	0·61	......	......
24	......	......	1·57	......
25	......	0·50	0·28	0·27
26	......	......	0·30	......
27	0·59	......	1·48	0·34
28	0·33	......	0·50	......
29	......	......	......	......
30	0·63	0·55	0·34	......
31	......	......	......	......

GRAFTING THE GRAPE-VINE.

BY

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Grape-grower, Nasik.

WE have great pleasure in publishing this article by an actual cultivator who has made experiments on his own account, and hope it would be of special interest to the readers of the Journal. It is needless to add that contributions from intelligent, practical cultivators, embodying the results of their experience, observations and experiments, will always be welcome to us.—[EDITOR.]

AMONG other advantages of grafting the grape-vine, it is claimed that the effect of grafting is to produce a constant weakening of the scion with increased fructification, a greater number of closely set bunches with large berries, more juicy and frequently richer in saccharine matter, and an early ripening.[1] Husmann also believes that grafting increases fruitfulness, the temporary obstruction seeming to have the effect upon the graft of making it produce more and finer fruit than on its own roots.[2] He has also recorded similar experience of other eminent growers.

The matter seemed worthy of investigation and led me to undertake a few experiments as already remarked in Bulletin No. 71 (of 1915) of the Bombay Agricultural Department. The principal varieties of grapes grown at Nasik are only four. Bhokari,

[1] Viala and Rivaz. "Grafting for American Vines."
[2] Husmann. "Grape-growing and Wine-making."

being a good cropper, is much in favour and largely grown, while Fakari, Sahibi, and Hafsi or Kali, being very shy bearers, are never grown beyond a few vines in a plantation, though these varieties are decidedly superior. If grafting produced increased fruitfulness the problem here was to ascertain whether some of our shy bearers could be made to yield more and better fruit by grafting them on other stock.

I had no clear notions about the influence of the stock upon the scion. I vaguely imagined that Bhokari, being very prolific, might exert a favourable influence upon the scion. Also, as Fakari, Sahibi, and Kali are very vigorous growers, producing abundant foliage—perhaps at the expense of fruit—I should be able to check this habit of vigorous growth by selecting a stock which was a moderate grower by habit, such as Bhokari. On these considerations I decided to use Bhokari as stock.

The next point was to select the method of grafting. Various methods of grafting and budding have been suggested. As I had very little experience in grafting, I chose to operate in four different manners, namely :—

(1) Grafted cuttings,
(2) Grafting by approach,
(3) Crown grafting, and
(4) Side-cleft grafting.

Grafted cuttings.

For successful grafting it has been found that the temperature should not exceed 20° or 25°C. As cuttings could only be obtained in the beginning of October, I tried grafted cuttings at this time, though the temperature condition was not favourable. All the trials failed successively for three years (1914 to 1916). In preparing the graft the cut has to be made one-half to one inch above and below a node upon the stock and scion respectively. This left the knitting surface much too small. The grafted cuttings should have been kept for callusing in fresh moist sand before they were set to root. I admit that I had not followed this instruction.

Be it from whatsoever cause, none of the grafted cuttings rooted, and I gave up the trials after three years.

GRAFTING BY APPROACH.

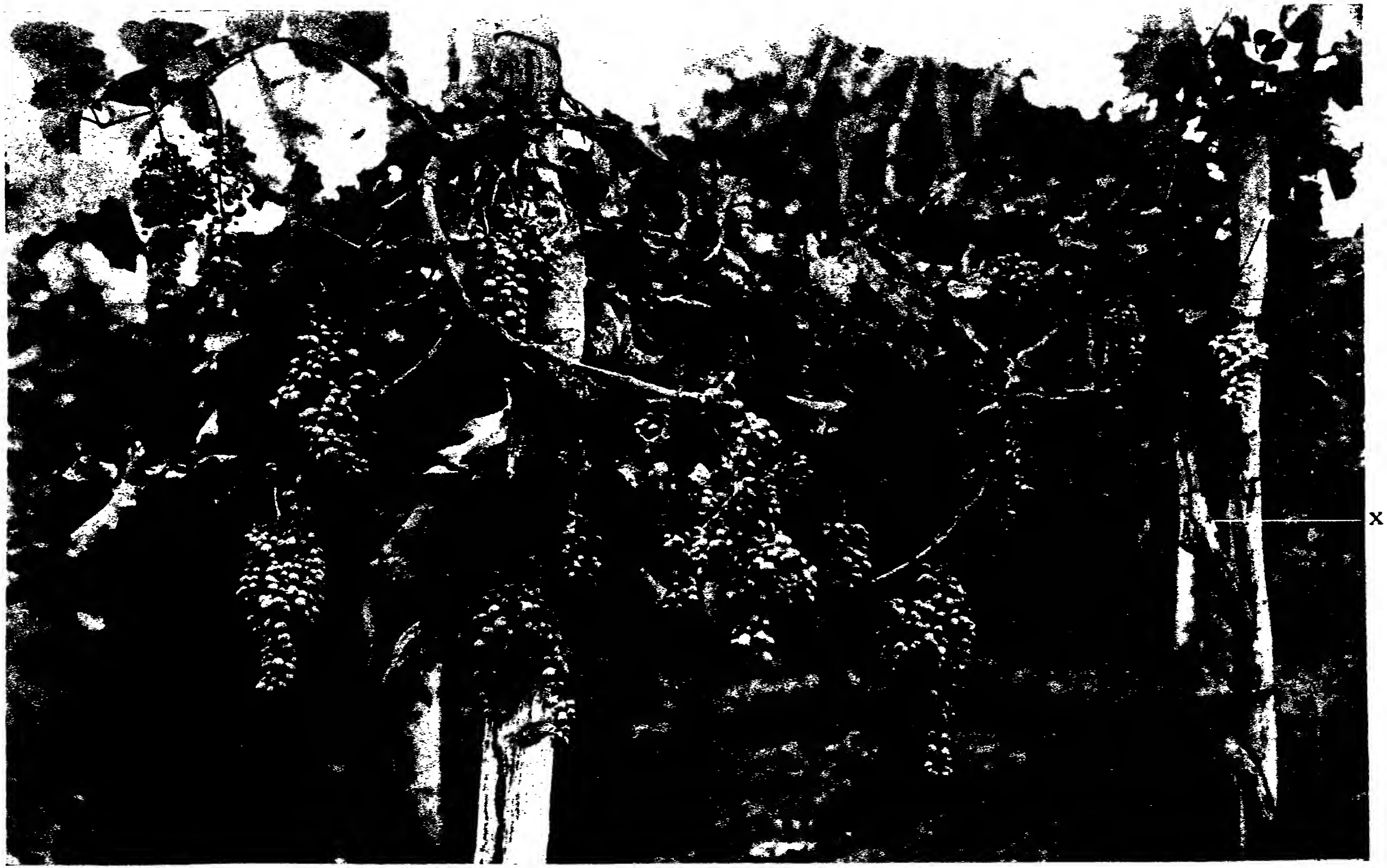
In 1913 a *mali* from the Ganeshkhind Botanical Gardens, Kirkee, grafted on two Bhokari vines in one of my plantations, operating by the usual method of grafting by approach (tongue graft). Both the grafts knitted well and were successful. Fakari canes were used for scions. Both grafts were pruned in April, 1914, to form the head. One of the grafts was accidentally destroyed while ploughing. The other graft was again pruned for fruit in October, 1914. The stock of this graft is 40″ long and the scion after heading in was 24″ long. It gave six bunches of good size, while there were only four small bunches on the parent vine, that is, from which the scion was taken. The result was tolerably fair and encouraging. This graft is bearing splendidly every year.

I have found that grafting by approach is a much surer method —the grafts knit well and the chances of failure are few. I have other grafts prepared by the approach method. One is bearing fruit beautifully. The length of the stock is 24″ and that of the scion after heading in is 40″. Three other grafts had to be transplanted elsewhere in April, 1917, as they happened to be in an isolated condition, but they have not as yet recovered from the shock.

But there is one disadvantage with this method. As the number of vines for the scion is only limited in a given plantation, only a few vines can be grafted by this method. I thought of trying a method which shall be quite independent of the position of scion vines, which is described below.

CROWN GRAFTING AND SIDE-CLEFT GRAFTING.

In October, 1914, I tried 10 crown grafts and 10 side-cleft grafts. Four crown grafts were put up below the ground and the rest above the ground. Only one graft above ground knitted well and was successful. Again, in the following year, out of nine crown grafts and nine side-cleft grafts, only one crown graft above ground was



Grafted grape-vine—Fakari on Bhokari. The cross indicates the union.

successful. The trials in 1916 and 1917 failed to give even a single successful graft. From this it appears that crown and side-cleft grafting are much more difficult and cannot be practised as a general method.

So far my object had not been attained. I wanted to find out a method of grafting by which the variety of any existing plantation can be changed at will. A new plantation can be put up by growing together and training mixed cuttings of different varieties, and when the heads are formed, the choice variety may be grafted upon another stock by the approach method. I have obtained a few grafts in this manner. But it takes up much time to train the vines before they can be grafted upon and, therefore, foreign varieties cannot be propagated rapidly by this method, nor can their possibilities judged within a short time. Crown and side-cleft grafting have a greater significance in the case of untried and foreign varieties; for, by these methods, these varieties can be introduced rapidly and their possibilities judged.

Results.

As a general rule, Fakari vines on their own roots bear quite indifferently. They will not bear fruit at all or bear a few bunches which are quite out of proportion to the large bearing surface on the head of the vines. All the grafts are bearing fruit regularly from the very second year. The quantity of fruit will depend on the bearing surface. As the age of the grafts advanced, the heads were well formed and the bearing surface had increased. There was a corresponding increase in the number of bunches and the weight of the fruit. I am writing this from my observations. I have not kept regular records. Last year the weight of fruit on the graft (approach graft of 1913) must have been 15 lb.; the other approach grafts yielded nearly seven pounds of fruit; the two crown grafts bore quite to my expectation. This year the approach grafts of 1913 had 42 bunches, which weighed 22 lb. (Birds are responsible for considerable loss of weight; only the actual weight is given.) The other approach grafts had 19 bunches which weighed 14 lb. The photograph of one of these two grafts (Plate I) will give a

good idea of the number and size of bunches. The number of bunches on the crown graft of 1914 was 17 and weighed 7½ lb., while the other crown graft of 1915 gave 13 bunches which weighed 6 lb. The bunches on both the grafts were mildewed, which circumstance has adversely influenced the weight. Many of the bunches were of large size. The berries attained normal size. On the other hand the berries on some bunches were undersized. Near each crown graft (close to it) is a companion or sister Bhokari vine which is also in bearing. The grafts are not photographed as it was difficult to isolate their bearing canes from Bhokari for the purpose of photographing. In one of my plantations there are 150 Fakari vines on their own roots. They bear fruit indifferently and are not even paying the cost of their cultivation. This is the first time in five years that they have borne fruit to an appreciable extent. The total weight of fruit on these 150 Fakari vines was 296 lb., or a little less than 2 lb. per vine. The average yield from Bhokari vines is 12 lb. to 15 lb. Individual Bhokari vines do bear 20 lb. to 25 lb. of fruit. From these figures it will be seen that the grafts gave considerably increased quantity of fruit, far in excess of the average of 2 lb. on the 150 Fakari vines on their own roots.

CONCLUSION.

It appears that grafting the grape-vine increases fruitfulness. The grafts give larger and closely set bunches. In some bunches the berries attained normal size, while in others they are undersized. The quality of the fruit is not changed appreciably. From the behaviour of four grafts, it is not safe to assert, as a general proposition, that grafting produces fruitfulness. The indications are, however, that it does produce increased fruitfulness. More experimental work is necessary. Experiments generally do not pay and are even costly. In other experiments with the grape-vines—such as summer pruning or pinching and spraying with ammonia copper carbonate solution against mildew—I have gained; while in trying the crown grafts I have lost 40 well-established vines and permanently injured 40 vines by side-cleft grafting. Besides, such experiments in experienced and capable hands are likely to be

more successful. If the record of my experiments be deemed interesting I hope others will undertake further experimental work.

Next cold weather, I shall grow and train 60 sets of mixed cuttings. Every set will consist of 4 cuttings, two of Bhokari and two of choice variety. Bhokari will be used for stock. For the scion, cuttings of Fakari, Sahibi, Kali, and Kandahari will be grown.

When the vines are established and heads are formed I propose to graft the choice varieties by the approach method.

SOME OBSERVATIONS ON AGRICULTURAL WORK IN EGYPT, AMERICA, AND JAPAN.

III. JAPAN.

BY

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(Concluded from page 280, vol. XIII, pt. II.)

I SPENT twenty-four days in Japan and confined my enquiries to the subjects of—

(*a*) agricultural education; and

(*b*) introduction of agricultural improvements.

AGRICULTURAL EDUCATION.

A great deal seemed to be going on in agricultural education, especially in technical and elementary schools. Agricultural education is in charge of the Department of Education in Japan.

Imperial University of Tokio. This has six Colleges or Faculties, *viz.*, Law, Medicine, Science, Engineering, Literature, and Agriculture; the latter has 33 professorial chairs and over 700 students in all. There are also 27 post-graduate students.

The university is well equipped and has attached to it an experimental farm together with a students' farm and a demonstration farm which seem to be very well managed. The average age of pupils entering universities in Japan is high, *viz.*, 23½ years. This is due to the long series of schools through which a pupil must pass before he can be admitted to the university. The course at Tokio lasts three years. The number of regular students is 452 with 286 pupils in addition undergoing special courses. A similar

Agricultural Faculty is attached to the Hokkaido University, but on a smaller scale. The undergraduate instruction is briefly as follows :—

Technical institutes. These are the lowest grade and take pupils who have finished the compulsory elementary education of six years. The number of pupils in these in 1908 was 163,300. The number of these schools now is over 5,000. In this connection I may note, some kind of technical subject is compulsory in the higher elementary schools. Three subjects are given, *viz.*, agriculture, manual training, and commerce, of which one or more is compulsory. The following table taken from the "Outlines of Agriculture in Japan," published by the Agricultural Bureau, indicates the system concisely :—

Educational organs of agriculture.

Jurisdiction	High educational organs		Ordinary organs		Organs for agricultural training
	University	Higher Technical School	A Class	B Class	
Department of Education	Agricultural College of University	Practical course of Agricultural College of University Higher Agriculture and Forestry School Higher Sericultural School Higher Horticultural School Training Institute of Agricultural Instructors	Agricultural School Stock farming School Horticultural School Sericultural School	Agricultural School Sericultural School	Agricultural supplementary School

Higher agricultural technical schools. These take graduates of the middle school or those equally qualified. The higher technical schools give a three-year course and turn out men qualified to teach in the middle schools and primary schools. In this class we may reckon the practical courses given at the Universities of Tokio and Hokkaido.

Agricultural schools. For these, pupils who have gone through the six years' compulsory primary course and have subsequently done two years' study in higher primary schools are admitted. The course in these schools extends over three or four years. Each

prefecture has one agricultural school of Class A, while many counties and towns have Class B agricultural school. I visited twelve of the various types of agricultural schools. The education is very general in all of them with agriculture occupying from two to six hours a week according to the class of school. The agricultural training is practical in all the middle and higher schools. I give below the time-table of the Shizuoka Agricultural School, course three years :—

First year	Hours	Second year	Hours	Third year	Hours
Morals ...	1	Algebra ...	2	Morals ...	1
English ...	2	Zoology .	1	Algebra ...	1
Algebra ...	2	L. Language ...	1	Economics ...	2
Botany ...	2	Chemistry ..	2	Chemistry ...	1
Japan L. ...	2	Physics ...	1	Pathology ...	1
Veg. culture ...	3	Morals ...	1	Gymnastics ...	1
Chemistry ...	2	Veg. culture ...	1	Sericulture ...	2
Chinese classics ...	1	Special veg. culture .	2	Drawing ...	1
History of Japan ...	1	Chinese classics ...	1	F. Language ...	2
Sericulture ...	2	Manure ...	1	C. feeding ...	2
Zoology ...	2	English ...	2	Veg. culture ...	1
Mathematics ...	2	Sericulture ...	1	Forestry ...	2
Drawing ...	1	Drawing ...	1	Japan Lan. ...	3
Gymnastics .	2	Insects ...	1	Surveying ...	1
Physics ...	1	Germs ...	2	Fruits ...	1
Entomology ...	1	Plant disease ...	1	Physics ...	1
Geology ...	1	Cattle feeding ...	2	Manure ...	1
Geography ...	1	Geography ...	1	Chemistology ...	1
Writing ...	1	Botany ...	1	Geometry ...	2
	30	Soils ...	1	Agri. law ...	1
		Forestry ...	1	Technical agri. ...	1
		History ...	1	Marketing of agricultural products	1
		Gymnastics ...	2		
			30		30

The course here is typical of most of the middle and higher grade agricultural schools. The subsequent career of graduates is given below :—

Shizuoka Agricultural School.

Graduates	588
At home	316
Government office	63
Various schools	76
Agricultural Society	19
Under counting or prefecture experimental station	21
To banks and other commercial houses	10
To higher agricultural school	19
Military service	34
In foreign countries	14
Dead	16

One of the best agricultural schools I saw was at Kyoto.

To bring out clearly the relation of agricultural education to general education I give below the ordinary school courses in Japan:—

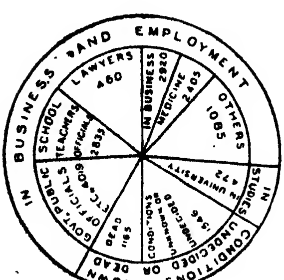
	General education.	*Agricultural education.*
(1)	**Six years' compulsory elementary education**	**None.**
(2)	**Two years' optional elementary education**	**Candidates who take this, have choice of 3 subjects, *viz.*, commerce, manual training or agriculture, one of which must be taken.**
(3)	**Middle school course, 5 years**	**Agricultural schools of Class B and Class A. These are of 3 or 4 years' duration and *do not lead* to University.**
(4)	**Higher and technical schools, 3 years**	**About 12 agricultural schools of this class exist. Similar technical courses exist in the University.**
(5)	**University**	**Agricultural College.**

It will be noticed from above that the elementary agricultural education tends to draw men from the regular road to the university. Thus the middle school course in agriculture is for boys of 14 or 15 to 18 years old and the bulk of them naturally go to their homes afterwards and do not look for appointments.

The inclusion of agriculture with three optional subjects in the two years' (optional) elementary education is also significant.

From the list of graduates of the Shizuoka School given above it will be seen that by far the greater number return to their homes. This was a school I would class as "Class A Middle School" and was a Prefecture School.

As to graduates of the higher technical schools, a great number of them go to appointments as teachers in lower schools and the education is so general that they are fit for any post in the lower schools.



I give here a diagram taken from the report of the Department of Education for 1914 as to careers of graduates of Tokio, Kyoto, Tohoku and Kyushu Imperial Universities (also including graduates of the old Sapporo Agriculture School).

The course to get through the university is so prolonged that comparatively few can afford to go through it. A great deal of

agitation was going on with a view to reducing the number of years in the full course (19 at present).

The number of students taking university courses in agriculture (400 regular and over 300 special courses at Tokio) does not seem high for a population of 70 millions and for a country with arge undeveloped tracts in Hokkaido, Formosa, Chosen, etc.

To grasp the length of the educational course in Japan one may imagine a boy of six years starting school. He finishes compulsory education at 12 or 13. Then follows two years' further elementary course, five years' middle school which brings him to 19 or 20 years old, and then perhaps three years technical or higher grade school before he enters the university. English is compulsory in all schools above compulsory elementary schools. Discipline is invariably excellent. Great stress is laid on loyalty. Drill and military training is a feature of all higher schools. The wearing of a distinctive uniform is very general in schools in Japan. The development of agricultural schools has been very rapid and in consequence many of the teachers are not well qualified, but on the whole I was much impressed with the headmen in all the schools visited.

In the short time at my disposal it was impossible to go into every detail, but the above is sufficient to show the great importance attached to elementary training in agriculture, a branch in which India at present is gravely behindhand. In America also a great deal was being done in elementary agricultural education, but I had no time to see any schools. I saw Texas and California State Colleges : they were doing good work and have courses very similar to our vernacular courses, besides the ordinary degree classes.

Agricultural improvement.

A great deal of work is in progress in Japan on rice—mainly varietal work. Some thousands of varieties seem to be grown and the subject is a difficult one. It seemed to me to be tackled on sound lines in most places.

Reorganization of holdings. Here is the most conspicuous success of this nature I came across. Already over 10 per cent.

of rice land has been readjusted into regular and compact holdings. To secure readjustment a majority of the farmers in any tract must be in favour. Formerly two-thirds majority was necessary, but the benefits were so soon realized that at present only a bare majority is required. Various bounties are given and certain remissions of land revenue to encourage the practice. A good deal of proselytizing goes on also and a persistent campaign is conducted in favour of it.

VETERINARY RESEARCH: SOME RECENT CONTRIBUTIONS.

EPIZOOTIC LYMPHANGITIS.

BOQUET, NÈGRE, AND ROIG.—FIRST ATTEMPTS TO PREPARE A VACCINE AGAINST EPIZOOTIC LYMPHANGITIS. *Bull. Soc. Path. Exot.*, Vol. XI, No. 7, July, 1918.

Hitherto it has not been possible to prepare a vaccine against epizootic lymphangitis because it has not been possible to obtain cultures of the parasite in series. The authors have obtained some cultures from Rivolta which have enabled them to make some experiments in this connection.

They have ascertained that animals that have been affected for a period of fifteen days or have recovered from the disease yield a serum that is rich in antibodies, and further that recovery from natural or experimental infection confers immunity.

It has also been observed during the treatment of the disease with sterilized cultures of the parasite that in the benign form the disease is checked after the fourth injection. The authors have, therefore, been led to try heated cultures as a vaccine.

For the preparation of the vaccine the growth obtained on the surface of Sabouraud's medium was first ground up in a mortar dry and then emulsified with salt solution, the salt solution being added in the proportion of about 30 c.c. to 20 cg. of culture.

The vaccine so prepared was sealed up in tubes and heated to 62°—64°C. for an hour.

Four injections of 5 c.c. each were given subcutaneously on the side of the neck at intervals of eight days.

Four horses were inoculated in the manner described without producing any lesions beyond a slight transitory swelling. Eight

days later two of the animals were inoculated subcutaneously with 4 c.c. of emulsion of culture which had not been subjected to heat; after a period of incubation of four to six weeks there developed in these animals either a generalized lymphangitis or a localized lesion at the point of inoculation.

No healthy horses were available to use as controls, but two rabbits were inoculated with the same culture as the authors had previously found that inoculation of rabbits leads to the formation of a local lesion.

The two horses vaccinated but not inoculated with living culture were kept under observation for three months without showing any symptoms of infection. It is, therefore, concluded that heated cultures can be injected with perfect safety.

Of the two horses which received both vaccine and culture one developed a sterile abscess at the seat of inoculation, and at the seat of inoculation in the other there developed a small nodule about the size of a pea, which disappeared eventually.

Both of the control rabbits developed abscesses in which cryptococci could be found, thus proving that the cultures had not lost their vitality or pathogenicity.

All the vaccinated animals were mixed haphazard with seriously affected animals, yet none of them contracted the disease.

The authors state that they do not draw any definite conclusions from their experiment, but state that it does indicate the possibility of inoculating against the disease with sterilized cultures, and that the investigation will be repeated.

NÈGRE, BOQUET, AND ROIG.—THE MYCOTHERAPY OF EPIZOOTIC LYMPHANGITIS. *Bull. Soc. Path. Exot.*, Vol. XI, No. 7, July, 1918.

In this paper the authors record their first attempts at treating cases of epizootic lymphangitis with vaccines prepared from artificial cultures which they have been able to obtain of the organism.

The vaccine was prepared in the same way as has been already referred to in another abstract dealing with the same subject taken from the same journal.

The vaccine was injected at intervals of eight days, and the initial dose was 2 c.c. The successive doses were increased by 1 c.c. up to a maximum of 5 c.c. which dose was not exceeded.

The injections were made on the side of the neck and the horses treated were not subjected to any other treatment; abscesses were not even evacuated.

In all, fourteen horses were submitted to treatment, but of these four could not be given the full treatment owing to difficulties of communication.

Of the ten animals which received the full course of treatment, eight made complete recoveries, while the remaining two which were the subject of severe disease of long standing died of intercurrent disease during the treatment.

A detailed statement of the ten cases is given, and these are divided into two groups according to whether there was cording of the lymphatics or not.

From the description of the detailed cases it would appear that in practically every case the injections of the killed vaccines caused abscess formation, and that recovery resulted in from one to three and a half months.

In a summary of the immediate results of the inoculations it is stated that during the first 24 hours there develops at the seat of inoculation a hot painful swelling about the size of the palm of the hand or a little larger. This swelling disappears in three or four days, but the area is still painful for several days longer. There is also a febrile reaction on the day following the injection, which lasts for two or three days.

NÈGRE AND BOQUET.—THE CULTIVATION IN SERIES AND THE DEVELOPMENT OF THE PARASITE OF EPIZOOTIC LYMPHANGITIS. *Ann. Inst. Past.*, Vol. XXXII, No. 5, May, 1918.

This long paper does not lend itself easily to summarization in a brief manner; a translation of the general conclusions drawn by the authors is, therefore, given :—

Pus containing cryptococci, taken aseptically from an unruptured bud and sown out upon an agar medium made from

horse dung and covered with a maceration of equine gland tissue, yields visible colonies which can be transplanted upon the same medium or upon Sabouraud's agar at first with and subsequently without the gland maceration. (Details of the preparation of the dung agar and the gland maceration are given in the body of the paper.)

With successive subcultures the cultivation of the parasite becomes more easy, and it develops more rapidly. After a number of passages it can be transplanted on to various media containing agar, gelatine, potato and carrot.

The optimum temperature for cultivation is 37°C. At this temperature the colonies upon Sabouraud's agar have a sandy yellow colour. They are wrinkled, and scattered over them are a number of little downy white spots. This downy appearance is more pronounced at lower temperatures.

When first sown out the cryptococcus becomes swollen and rounded, and drops of oil make their appearance in its interior. It then develops double contoured mycelial threads which produce external spores.

In subsequent subcultures the young colonies are composed of septate mycelial tubes with thin walls.

In older colonies these filaments disappear after having produced external spores by a process of budding. The latter give rise to septate mycelial tubes with a double contour and to chlamydospores. They are identical with those which arise by a process of budding from the rounded forms of the cryptococci.

The rounded form of the parasite as it occurs in primary cultures and the external spore are therefore the points of origin of exactly similar thread formations, and it would appear that the cryptococcus is the form of multiplication within the body which corresponds to the external spore.

We have established the fact that the parasite is able to multiply in the horse's skin in the form of the threads referred to above—that is to say, as tubes showing a double contour and external spores. According to one of our observations, which requires confirmation, the cryptococcus is developed in the horse's skin by a process of

budding from the external spore. At the moment when budding takes place the spore has only a thin wall.

In old cultures the segments of the mycelial tubes become detached from each other and have a twisted appearance.

Horses inoculated by scarification or intra-dermally with cultures of the parasite develop abscesses containing the cryptococcus. Subcutaneous inoculation results in the formation of abscesses which may subsequently become generalized by way of the lymphatics, thus producing the clinical picture of the natural disease.

Cryptococci appear in the lesions from three to four weeks after inoculation. They are at first free and appear as small ovoid bodies with thin walls. They then acquire a double contour, and the majority of them are to be found within the leucocytes.

The serum of diseased animals gives a positive result by the fixation test with cultures of the parasite. Antibodies can be shown to be present in the blood about the twentieth day after the disease makes its appearance. They persist for a long time after recovery.

A horse which has recovered from a primary attack of lymphangitis is resistant to a second inoculation with culture.

To sum up, we have succeeded in obtaining the development of the cryptococcus in the mycelial form. We have been able to obtain cultures of the organism in series.

We have established the multiplication of the parasites in the horse's skin in exactly the same form as in cultures.

We have reproduced the disease experimentally by inoculation with cultures and have shown that the cryptococcus makes its appearance and develops in the lesions produced.

We therefore think that the cryptococcus is the multiplication form within the horse's body of the organism which we have described.

The parasite will only be able to be classified when its sexual method of reproduction is accurately known.

RINDERPEST.

YOUNGBERG.—THE IMMUNITY TO RINDERPEST OF NELLORE (INDIAN) CATTLE AND OF VARIOUS NELLORE-NATIVE GRADES. *Philippine Agricultural Review,* Vol. X, No. 4, 1917. (Ex. *Trop. Vet. Bull.,* Vol. VI, No. 2, 1918. Original not available.)

It has been found that Nellore cattle adapt themselves readily to the conditions in the lower altitudes of the Philippine Islands and that when crossed with Native or Chinese dams a good type of animal is produced.

The idea was prevalent among Philippine breeders that the immunity possessed by Indian plains cattle to rinderpest could be transmitted to half-bred progeny. The author produces evidence both from field and experimental sources which shows that this is not the case.

The following conclusions are drawn up :—

(1) The pure Nellore cattle are very highly resistant to the Philippine strains of rinderpest, the mortality being insignificant. They are not, however, absolutely immune.

(2) In the case of Native cattle the infectivity of the virus is not appreciably attenuated by being passed through Nellore cattle. This fact makes the latter very dangerous as conveyors of disease, as they may react without showing clinical evidence.

(3) The half-bred Nellore cattle do not inherit the high degree of resistance to rinderpest possessed by the Nellore stock. In infections of moderate virulence they apparently have somewhat more resistance than the Native animals, but in virulent infections this resistance does not afford them any protection.

(4) From the inconclusive evidence at hand, the three-fourths Nellore-Native grades appear to have a greater resistance than the Native stock.

(5) The rinderpest problem of the Philippine Islands cannot be solved by the importation of Nellore or other Indian cattle unless possibly by carrying it out to the extent of practically eliminating the Native stock.

PARASITOLOGY.

CHATTON.—MICROFILARIA OF THE DOMESTIC CATS IN SOUTHERN TUNIS. *Bull. Soc. Path. Exot.*, Vol. XI, No. 7, July, 1918.

The parasite figured and described in this note was found in two out of twenty-six cats examined.

In one of these they were scantily present in the blood at post-mortem, and in the other fairly numerous.

There is no information as to whether the parasite is present periodically in the blood.

The parasite appeared to be devoid of any sheath. In preparations fixed with osmic acid, it ranged from 240 to 350 microns in length, and from 7 to 9 microns in thickness. In view of the fact that the longer parasites were thinner than the short ones, it would appear that the differences in thickness were accounted for by contractions. The anterior end was obtuse and the posterior very slender.

There was no discoverable striation of the cuticle. The author thinks that the parasite bears some resemblance to *Filaria imitism* which is known to occur in Tunis.

YAKIMOW, SCHOCHOS, KOSELKINE, WINOGRADOW, DEMIDOW.—MICROFILARIASIS OF HORSES IN TURKESTAN. *Zeitschr. f. Infektions Krankh. etc. d. Haustiere*, Vol. XVI, No. 4, 1915. (Ex. *Trop. Vet. Bulletin*, Vol. VI, No. 2, June, 1918. Original not available.)

Examination of horses in military and civil possession in Turkestan showed that the former were far more severely affected than the latter. The maximum percentage infected in military units was 37·6. The maximum discovered among civil horses was 8·1.

The symptoms presented were abrasions of the skin due to irritation, especially about the nostrils, œdematous swellings of the chest, abdomen and limbs, and in some cases rapid exhaustion and dyspnœa when the animals were put to work.

The hæmoglobin content of the blood fell to 60 per cent. There was very marked eosinophilia, lymphocytes were increased in numbers and polynuclear leucocytes showed a corresponding decrease.

The filariæ possessed a sheath which projected beyond both ends of the body.

The body of the parasite, which was rounded anteriorly and tapered posteriorly, measured from 159 to 267 microns; while the total length of the sheath ranged from 270 to 323 microns.

No diurnal periodicity was observed, and subcutaneous inoculations of infected blood into a horse, ass, and two sheep failed to produce infection.

Intravenous injections of salvarsan were without effect.

The authors believe that this parasite differs from those previously described as occurring in horses and suggest the name *Microfilaria ninæ kohl-yakimovi* for it.

MOUCHET.—SOME ANATOMICAL LESIONS PRODUCED BY NEMATODES. *Bull. Soc. Path. Exot.*, Vol. XI, No. 7, July, 1918.

The author describes in this paper some lesions which he found in the organs of a leopard which had been poisoned with strychnine on account of the depredations it caused among goats at Kangomba (Tanganyka).

The whole of the intestinal wall starting from a point 20 centimetres from the stomach to a point 30 centimetres from the cæcum was scattered with nodules which numbered about a hundred. They projected from beneath the serus membrane, were about the size of peas, and were of a bluish colour. The nodules were cystic and the walls were from two to three millimetres in thickness. Inspection of the mucous membrane showed that the cavities of the cysts communicated with the lumen of the intestine by small openings about one millimetre in diameter. Each of the cysts contained several worms from one to two centimetres in length. A small number of the cysts appeared to have no orifice leading into

their intestines, this was particularly the case with the smallest of them.

The worms were identified by Railliet as *Galoncus perniciosus*.

VAN SACEGHEM.—GASTRODISCUS ÆGYPTIACUS (COBBOLD, 1876). *Bull. Soc. Path. Exot.*, Vol. XI, No. 5, May, 1918.

Although the author's observations are incomplete owing to his having been compelled to leave Zambi where he was working, he gives the results of some of his investigations.

The eggs of *Gastrodiscus ægyptiacus* are easily discoverable in fresh fæces of infected animals. They measure 150 to 170 microns in length by 90 to 95 microns in width.

Apart from a polyhedral shaped mass in the centre the eggs show no evidence of segmentation at the time of laying. After three weeks' exposure to a temperature of about 28°C. (the average temperature of the laboratory) the contents of the eggs become very granular.

Segmentation takes place whether the eggs are kept in a liquid medium or not. After some days a little vermicule is visible in the egg. This executes intermittent movements and is ciliated.

The miracidium having escaped from the egg maintains its vitality and executes rapid movements if the escape takes place in water. If moisture is not present it rapidly dies. The larva measures about 160 microns in length by 73 microns in width. The anterior extremity is rounded and not pointed as in the case of the miracidium of *Fasciola hepatica.* In view of the facts that enormous numbers of horses harbour this parasite in very large numbers, and that a country very rapidly becomes infected with the parasite, the natural conclusion is that the intermediate host of the parasite, if one is necessary, must be an extremely commonly occurring one. The author thinks it is probably a common mollusc.

The parasite is, as a rule, not responsible for serious disturbances of health, but it may assist in producing ill health in animals in poor condition.

Infected horses not infrequently suffer from colic, and the author has found tincture of opium with the addition of ether the best treatment for this.

Arsenic appears to be valueless for the expulsion of this worm.

The only prophylactic measure that can be adopted is to prevent horses drinking on marshy ground and feeding grasses cut in marshy places.

VAN SACEGHEM.—THE CAUSE AND TREATMENT OF GRANULAR DERMATITIS. *Bull. Soc. Path. Exot.*, Vol. XI, No. 7, July, 1918.

According to the author of this paper the cause of summer sores is the larva of *Habronema muscæ*.

Some larvæ of *Musca domestica*, which had been bred in the laboratory, were placed in the dung of a horse known to be infected with *Habronema muscæ*.

Seventy per cent. of the flies which developed from these larvæ were found to be infected with the larvæ of *Habronema muscæ*.

This infection takes place during the larval stage, but not during the nymphal stage.

The larvæ of *Habronema* are capable of surviving for 12 hours in a liquid medium. If they are placed on the hair, or on a shaved area of skin of a horse, they show no tendency to pierce the skin, but if placed on lesions covered with serum they show a great tendency to penetrate.

The author has observed small parasitic nodules on the membrana nictitans and has produced the same lesions experimentally.

Treatment is both prophylactic and curative.

The administration of arsenic in doses of 1 to 2 grammes daily should, in the author's opinion, be beneficial in destroying the larvæ in the horse's stomach.

Since the larvæ are rapidly destroyed in manure heaps which are generating a good deal of heat, it is possible to reduce the chances of infection by burying the fresh dung daily in a fermenting heap.

By this means both the larvæ of the worms and of the flies which are likely to become parasitized may be killed.

During the hot weather all wounds should be dressed with dry powder dressings.

As a curative dressing for wounds already infected, the author advises a powder composed of "plaster" 100, alum 20, naphthaline 10, quinine 10 or some other bitter powder. Such a powder keeps off flies, is very adherent, causes rapid drying of the wound, and on account of its bitter taste prevents the animal from biting itself.

TRYPANOSOMIASIS.

SERGENT Ed. AND ET., FOLEY AND LHÉRITIER.—THE MORTALITY IN EL DEBAB TRYPANOSOMIASIS OF THE DROMEDARY. *Bull. Soc. Path. Exot.*, Vol. XI, No. 7, July, 1918.

According to Algerian camelmen El Debab in the dromedary runs a course ranging from some months to several years, and usually terminates fatally.

The authors have had under observation a couple of naturally infected animals. Both died four months after infection.

An experimentally infected dromedary appeared to have made a complete recovery after one and a half months.

It is pointed out that bad management is not infrequently a predisposing cause of death among infected animals. On the other hand, the absence of clinical symptoms often leads to the death of animals being attributed to bad management, whereas they are in reality infected with trypanosomes.

About 10 per cent. of Algerian dromedaries are infected.

VELU.—OCULAR AND LOCOMOTOR DISTURBANCES IN EQUINE TRYPANOSOMIASIS IN MOROCCO. *Bull. Soc. Path. Exot.*, Vol. XI, No. 7, July, 1918.

Lesions of the eye, while fairly constantly observed, have not the same importance as the disturbance of the locomotor apparatus.

The conjunctiva may be distinctly yellow, but this is sometimes masked by congestion. Petechiæ of various sizes are present. These are at first red in colour but subsequently acquire a purple tint.

The eyelids are œdematous and the eyes half-closed. There may be erosion of the conjunctiva associated with profuse lachrymation.

These lesions may be present in varying degrees of severity. The locomotor disturbances are by far more constant, but these also vary in severity from case to case. They range from mere weakness, which is usually more pronounced in the hind limbs, to actual paralysis.

On a number of occasions the author has observed complete inco-ordination during febrile attacks. In every case in which locomotor disturbances have been pronounced, there has been incontinence of urine.

MISCELLANEOUS.

McCulloch.—The Stability of an Alkaline Hypochlorite Solution. *Jl. R. A. M. C.*, Vol. XXX, No. 5, May, 1918.

The experiments detailed by the author of this short paper were carried out with the object of ascertaining the value of an alkaline hypochlorite solution as a sterilizing agent—such a solution having been put on the market as an efficient water sterilizer. The experiments were carried out at Wellington, India. The author concludes that a solution containing calcium hydroxide, calcium hypochlorite, and sodium hypochlorite, with an average amount of available chlorine of 3·5 per cent., of which 0·35 per cent. was in the free state, is not much more stable than bleaching powder and is of little value as a stable sterilizer in tropical countries.

Selected Articles.

SILK AND SILKWORMS IN THE FAR EAST.

Being information gathered during a recent visit to China, Japan, Korea, Manchuria, and French Indo-China.

BY

COMMISSIONER AND MRS. BOOTH-TUCKER.

I. SOUTH CHINA.

Canton. The Canton variety of silkworm is a multivoltine, producing crop after crop in quick succession all round the year. It is closely related to the Mysore silkworm, and produces small cocoons but with a very good quality of silk. The cocoon is not worth exporting, except in the case of pierced cocoons which are exported as waste silk. The price when we were at Canton averaged about 83 dollars per picul of 133 lb.

In regard to colour of cocoons and silk, this varies. There are some which are the same light greenish colour as the Mysore and others which have the rich yellow of the Bengal, but the bulk are pure white, and only the last mentioned are used for producing reeled silk for export.

There are large filatures engaged in reeling this silk which is eagerly bought up by foreign merchants.

A very large proportion, however, of the cocoons are reeled and made into silk fabrics in China.

There are a number of small weaveries in Canton working with Chinese handlooms of a very ancient pattern. The work turned out is, however, excellent.

It was noteworthy that a great deal of the raw silk is put on the looms without being bleached, the fabrics being bleached afterwards. On the other hand, a good deal of the raw silk is bleached before being put on the looms.

On some of these old-fashioned looms patterns of beautiful design are worked by means of a very ingenious "Jacquard" arrangement, if so it may be called, a weaver sitting above the loom and pulling an intricate number of threads to work the healds. No arrangement appears to have been made in Canton for introducing the much more simple Jacquard attachments, although the present plant certainly produces very satisfactory results.

The Silk Expert who kindly assisted us in our enquiries and who had had eight years' experience in the country, told us that he did not know of any school in South China for the instruction of the Chinese in superior methods of either rearing worms, reeling silk, or weaving, but the industry is so extremely ancient and the Cantonese are so very painstaking and careful in attending to details, that the whole industry is carried on with great success both as a cottage industry and otherwise. Recently, however, large filatures have been organized on the European model, and these appear to be very prosperous.

II. North China.

We visited Shanghai, Pekin, and Mukden, and made enquiries at various centres. Here we found three excellent varieties of cocoons, namely, Wusih, Shewshing and Hupeh. Experts whom we consulted told us that, in their opinion, the Wusih and Shewshing, which are white cocoons, are superior in quality to the Italian.

The extreme care and attention which is given by the Chinese to the cultivation of their silkworms, and the long period that the industry has existed will account for its great success. Government is now taking considerable trouble to establish silk schools in different parts of the country, so that improved methods may be introduced.

We were able to get a supply of Wusih and Shewshing eggs forwarded to us and have hibernated them in Simla and are sending them out to various centres throughout India, as well as to all Government institutions with which we are acquainted. This we are doing free of charge although the experiment has cost us a good deal, as we are satisfied that one, if not both, of these varieties,

may be of extreme value to us in India and may be better suited to the climate than either the French or Italian varieties. We have asked the different centres to which the eggs are being sent to kindly report the result. The North China cocoon harvest is in June and July in the hot weather, and hence it is probable that this kind of silkworm would be well suited to India.

The North China silkworms are univoltine and the cocoons, as in the case of other univoltines, are far superior to the multivoltines of South China.

We may here remark that the univoltine variety has one great advantage over the multivoltine, inasmuch as its care does not interfere with the growing of the ordinary crops. It is usually produced at a time when agricultural labour is, comparatively speaking, free, and helps to supplement the revenue from other crops without interfering with them.

In making investigations on this question in France and Italy, experts there said to us that they did not care to introduce multivoltine varieties into Europe because it was found that they interfered with other and more profitable crops, which was not the case with the univoltine. This is a point which should be borne in mind. The agriculturist naturally looks for profit and the introduction of a crop which pays better than silk has been known in some localities to lead to a wholesale destruction of mulberry trees, as was the case some years ago in parts of Italy.

There is an immense demand for the above three kinds of cocoons in the Chinese filatures and high rates prevail so that the cultivation is extremely profitable to the people. The Yang-tse-Kiang river forms a splendid highway for their transportation to the filatures on the coast, and this, in the absence of railways, helps in the production.

Both the Shewshing and Wusihs are pure white cocoons, while the Hupehs are a rich golden yellow. The Hupehs appear only to have been recently introduced to the filatures and were at first looked upon as inferior. In fact reelers in some of the filatures refused to use them, showing how strong is the feeling in China in favour of white cocoons as opposed to yellow. It was necessary

in some of the filatures to begin with two or three basins and gradually work up others.

The Wusihs are produced in a flat level country very like Bengal or the Gangetic valleys, the summer heat being very great. The Shewshings are produced in a somewhat hilly country at an elevation of about one thousand feet. The Hupehs come from the interior of China.

The mulberry is mostly planted in the form of dwarf trees two or three feet high, planted very close. Lately bushes have been introduced, but as a rule only one or two stems are allowed to grow, and these are cut down yearly. The leaves are stripped off and fed separately, and the worms are reared on large round trays. The custom for cocoonage, *viz.*, for the mounting of the silkworms to produce cocoons, is to place bundles of grass, tied at the bottom with their heads spread out. Women gather the worms in baskets when they appear to be ripe and go round placing them on the top of the bundles of grass to spin. The method is somewhat primitive, but answers its purpose.

Another plan is to have a long straight rope with flat stars inserted at intervals on which the worms are cast to spin. They are not encouraged to "mount" of their own accord.

The Chamber of Commerce and the French Consulate in Shanghai are endeavouring to introduce improved methods amongst the rearers.

The filatures are quite up-to-date, and the basins which we saw had five, six, and even eight buttons working. Women are mostly employed in doing the reeling, while men supervise and watch the work.

It is not found necessary to re-reel, as the reeling itself is extremely good. In a filature which we visited we were told that all the raw silk they produced was marked as 100 tavelle, that is, without any breaks, while the variation in denier was merely fractional. At the time of our visit this raw silk was fetching 7 American dollars per pound (not kilo.), equivalent to Rs. 21 per lb.

Where large numbers of buttons are worked, the cocoons are prepared for the reelers by girls and the breaks are mended by

separate women who are employed for the purpose. It is a little remarkable that they are paid by the day and not by results. If, however, they do not produce a fair day's work, they are fined. Owing to the high price of raw silk and the strong demand for it, the number of filatures has enormously increased of late.

The godowns for storing cocoons which we visited were nothing like so up-to-date as those which we visited in Srinagar. They are a good deal troubled with rats in the godowns, but rely on cats and traps for keeping these down—they are not able to use poison. The raw silk was packed with extreme care and not in the apparently rough and ready manner which prevails in Kashmir.

Silk-weaving in Pekin. We visited a very interesting weavery in Pekin which was much more up-to-date than the weaveries of Canton. They had imported Jacquard attachments for their hand-looms from Japan, and these were being very successfully worked, many excellent fabrics being produced.

Everywhere, both in South and North China, one could not help being impressed with the fact that the enormous production of cocoons in the country facilitated the manufacture of cheap silk fabrics, and that in this respect India could not hope to compete with either China or Japan till she had established a sufficient production of cocoons. The success of the industry was based on the existence of the raw material.

III. Manchuria.

Manchurian tussor. Authorities claim that the cultivation of the Manchurian tussor preceded that of the domestic variety. The rearing area which originally occupied the Peninsulas of Liaotung and Shantung gradually spread eastward to the valley of the Yalu, Chefoo and Antung, being now the principal commercial centres.

Operations were considerably interrupted by the Chino-Japanese and Russo-Japanese wars. But since their conclusion the industry has advanced with extreme rapidity.

This variety of tussor feeds on four kinds of silkworm oak. The system of growing these in dwarf plantations appears to

be well worth considering for application to the Indian tussor and muga.

The trees are planted by the Chinese about 3 to 5 feet apart, about 12,000 acorns being planted to the acre. Holes are dug about 6″ to 1′ deep and several acorns are placed in each. They are not manured. They sprout in spring, and the weaker growths are then removed. After two or three years there is a fair growth, and they are then cut back usually to the height of a foot and are used for feeding the following spring. The trees are never permitted to exceed 5 or 6 feet in height.

There are two methods of pruning adopted :

1. The umbrella method, in which the tree is pruned to a height of two or three feet above the ground in the shape of an umbrella.

2. The tree is cut down at about one inch from the roots, sending out new shoots with dense foliage the following spring.

The pruning is carried out after the gathering of the autumn crop.

A well regulated plantation will include trees of various ages, the youngest or recently pruned being reserved for young worms, and those with more mature foliage for older worms.

The trees have to be renewed from time to time as the leaves become small, hard and unsuitable for feeding.

In the new districts trees are propagated by cuttings rather than seeds. Branches are selected from a growing tree, about 1″ in thickness and 3′ in length. Late in the autumn these are inserted in the ground to a depth of 9″. They sprout in the following spring, and 3 or 4 worms can be reared on them, the number being increased to 12 and 20 in the following two years.

The droppings from the worms manure the trees and increase the supply of leaf.

The dwarf plantation has the great advantage that the worms can more easily be removed from tree to tree, and protected from their bird and insect enemies.

There are two crops, of which the autumn one is the best.

There are several systems followed for hatching the eggs.

1. Indoors, the young worms not being taken out to the oak plantation until after the first moult.

2. After separation from the male moths, the females are taken to the plantation and tied to the branches of the trees till they deposit their eggs.

3. In Japan the eggs are kept in a box, and about ten days before hatching are pasted with starch to egg cards, each of which bears about 60 eggs. These cards are then fastened to the trees, and the paste prevents the eggs being washed off by rain.

When the eggs are hatched on the first system indoors, the young worms are fed on young branches of oak, two or three feet long, tied in a bundle and placed in vessels containing water, care being taken to prevent them from descending into the water and being drowned. This method is termed the "Han Tun."

Another plan is known as the "Shui Chang" or water yard. Branches are similarly cut and placed in the mud or sand on the banks of a mountain stream. In both cases care must be taken that the place is sheltered and not too exposed to the wind.

The above details show the extreme attention to detail bestowed by the rearers, both on the growing of the food tree and on the care of the worms, contrasting very strikingly with the careless, slipshod methods prevailing in India, and resulting in the rapid deterioration and destruction of what might become a valuable asset in her commercial, agricultural, and industrial prosperity.

For further information on this subject, see Norman Shaw's "Manchurian Tussor Silk," Fauvel's "Silkworms of Shantung," and Palen's "Wild Silkworm Culture in Manchuria."

At the same time it has to be remembered that the tussor silkworm cannot as a rule be compared from a commercial and profitable standpoint with the domesticated varieties, and it would in our judgment be a mistake to concentrate attention upon it in the present stage of the silkworm rearing industry in India.

The thread of the tussor is flat, making it difficult to combine with other fibres, while that of the domesticated *Bombyx* is round. It also lacks in brilliancy. The market likes it mainly if and when it can be obtained cheaply, and often, as in the case of the eri, at

"waste" rates, which may not pay to produce, and which cannot ordinarily compare with the prices commanded by mulberry silk.

IV. Japan and Korea.

In Japan we were very kindly received by Prof. Honda, President of the Imperial Sericultural Institute, who gave us much valuable information regarding the industry in Japan. This college has a staff of about 40 professors and teachers and is extremely well organized. Professor Honda himself has written a most excellent treatise on silk in Japan, containing a quantity of information which should be very valuable for use in India. We have supplied this book to our silk schools.

There is no doubt that the organization of the silk industry in Japan is far ahead of that in any other country. The Japanese are born organizers, and one has only to travel through their country to see with what care they collect the most exact details calculated to contribute to the success of the industry, and how lavish they are in their expenditure in doing for silk what no private individual or organization can do for it.

The college is a commodious building, wooden, inexpensive, very simple, covering nearly the whole ground on which it is located. At the time of our visit there were 200 students. The ordinary course for students covers two or three years, and those who were admitted must have certain educational qualifications.

In spite of the great heat at the time of our visit—it was in July—the worms seemed to be doing well in all stages with the thermometer going up daily to 90° and 95° Fahrenheit. They did not appear to suffer in any way; nor was there any attempt made to keep them cool beyond having them on the ground floor of a double-storied building with ample ventilation, while the leaf was kept in a cool cellar, damped, so as to prevent its losing its juiciness and becoming dry through the heat. The professor told us that all over Japan similar conditions existed, and that the worms there did not suffer from this extreme heat.

He informed us that throughout Japan the worms were fed on bush mulberry, and he did not consider it necessary to have tree

mulberry, but that there were a great many different varieties of mulberry—between two and three hundred in all—and some were far better than others and produced better results. Great care was taken moreover in feeding the young worms on young leaves and the older worms on matured leaves.

In travelling through Japan we noticed the absence of tree mulberry, and that in some cases instead of bush mulberry there were dwarf trees. We noticed also that the greatest care was given to the cultivation of the mulberry plants. The plantations were absolutely weedless, well manured and cultivated, and, in almost all cases, irrigated. Hence, in spite of the great heat there was a full and abundant supply of leaf which seemed juicy and tender. Again, instead of the poorest soil being given to it, as is so often the case in India, so far as we could see, the best and richest soil was being utilized for growing mulberry. Evidently, in the opinion of the Japanese, no soil was too good for the food of the silkworm. We asked the professor whether there was any special reason for preferring bushes to trees. He replied that trees were much more liable to disease, and hence the preference for bushes. It was much easier also to pick the leaves, and the bushes could be planted far more closely than trees.

Grainage. The utmost care is given to grainage, or the production of disease-free eggs. No one may produce eggs without a license, and a staff of something like 3,000 inspectors is employed in inspecting the licensees and watching that no diseased eggs are allowed to be produced. The ordinary rearer of silkworms was forbidden to grow seeds either for himself or for others.

Hibernation. The best way of storing eggs was, in the opinion of the professor, in windhalls, or caves, which were dug in the side of hills. Positions were found in the slope of a hill facing north, where there was reason to believe that there would be a natural current of air from inside, and here a *pakka* cave was made about 20 feet in depth right into the side of the hill. It was essential that there should be natural draught, hence the name "windhalls." Coming from inside, it secured a uniform temperature, throughout the hottest weather, of from 30° to 40° Fahrenheit. It was built

out of the hill with some sort of trellised doors so that the wind could get out freely all the time and play upon the eggs, which were simply arranged in shelves. Another system of hibernation was the usual snow-pit, while another was the artificial refrigerator. This last was very complex and expensive and did not appear to be particularly favoured by the professor, though one was in operation in the grounds of the college. He considered the windhalls were the most suitable. In these, eggs could be stored right through the hot weather. This was important as the Japanese have now two harvests of cocoons, one in the summer—the most important—and another in the autumn. The eggs for both are the univoltine variety and are the previous year's layings, being preserved in the windhalls till they are required for use.

This is an extremely important point for India, owing to the fact that in a great part of the country the mulberry produces its best supply of leaves after the south-west monsoon, and the regularity of this monsoon would probably enable a very good crop of cocoons to be produced at this time. At present the attempt to keep the eggs artificially till they are required at the end of the monsoon has not been a success, but the windhalls may get over this difficulty.

On the point of re-reeling, the professor told us that it was the universal practice in Japan to re-reel their raw silk. This was not in order to get the tavelle perfect, but because of the dampness of the climate. It was not necessary in China, and would not be in other places where the climate was not so damp as that of Japan.

In Korea the Japanese have made great efforts for the extension of the silk industry, and the prospects seem excellent. [See Japanese official report on the administration of Chosen (Korea).]

It is important to note that in Japan, from the Emperor's household downwards, the whole country takes an interest in the rearing of silkworms.

I. The Empress herself has a mulberry garden inside the palace grounds and cultivates silkworms with a view to encouraging the industry.

II. The Government also throws itself heart and soul into the industry—

(*a*) Sericultural Institutes. There are two important institutes supported by Government, one in Tokio and the other in Kioto.

(*b*) Prefectural Schools of Sericulture are also established in four different Prefectures.

(*c*) There are also thirteen Sericultural County Schools, besides many private schools.

(*d*) There are eight Prefectural Institutes of Sericulture and five County Institutes, while private institutes are innumerable, and there are a number of temporary institutes and training places opened during the rearing season.

(*e*) Agricultural Colleges, Forestry Schools, and Agricultural Experiment Stations give training in sericultural courses. These institutions, when not supported by Government, Prefecture, or County, are liberally subsidized by them. Subsidies are also given by Government for enlarging mulberry plantations.

(*f*) Circuit Lecturers are employed by Government, Prefectures, Counties, Towns and Sericultural Associations. They are sent round to give direct guidance and encouragement to those engaged in the industry. Some of these circuit lecturers are employed all the time, while others are only employed for the season. They are supplied from among the graduates of the above mentioned schools and institutes.

(*g*) Competitive Exhibitions. Numerous exhibitions are held in the different parts of the country to give encouragement to sericulturists, by collecting and exhibiting their products, thus giving stimulus for the betterment of the industry. Prizes or certificates of excellence are given. At least 50 such exhibitions are held annually.

(*h*) Precautions against silkworm disease. Special laws are passed and strictly enforced for the prevention of disease. The offices for the prevention of silkworm diseases number 132, while the staff thus employed amounted, in 1909, to 3,175 persons. The annual expense for this one purpose, paid by the Central or

Prefectural Governments, reached the vast sum of one million yen, say, 20 lakhs of rupees.

"*Conditioning*" *of raw silk.* Government has established a "conditioning house" by special act of legislature in Yokohama. This we visited. No charge is made by Government for conditioning the silk, but there is an ingenious arrangement by which this institution is entirely self-supporting. The actual number of tests performed in the Silk Conditioning House in 1908 amounted to no less than 97,723.

III. *Sericultural Associations.* In addition to Government support, numerous Sericultural Associations have been established. The Sericultural Association of Japan has as its honorary president and patron the Crown Prince, with 30 councillors appointed from amongst influential men in the sericultural circle. Its board of investigation includes many noted scholars and sericulturists throughout the country, while its membership has reached to 60,000. This Association has its branches in every Prefecture throughout the country. Another similar Association exists with a membership of 40,000. A third has a membership of 36,000. In addition to this there are—

- 67 Sericultural Guilds.
- 35 Silkworm Egg Guilds.
- 21 Raw Silk Guilds.
- 1 Silkworm Rearers' Guild.
- 2 Silkworm Rearers' and Silkworm Eggs Producers' Guilds.
- 5 Sericultural Guild Unions.
- 1 Raw Silk Producers' Guild Union.

Special laws have been enacted to assist these Guilds and have resulted in immense benefit to the members.

IV. *Co-operative Credit Societies.* Under the Co-operative Societies Act passed in 1898, 2,442 co-operative credit societies have been formed for sericultural purposes, being 57 per cent. of the total number of Industrial Co-operative Societies existing in Japan.

V. *Cultivation of Mulberry.* The total area of mulberry farms in Japan was, in 1907, 957,552 acres, being 7·44 per cent. of the total

cultivated lands in Japan and over 16·2 per cent. of the total farms. These are steadily increasing year by year. In the Prefecture of Gumma 31·5 per cent. of the cultivated lands are devoted to mulberry; in Yamanashi 30·2 per cent.; in twelve Prefectures the percentage ranges from 10 to 31 per cent.; in eleven others from 5 per cent. to 10 per cent.

Nothing is more remarkable than the extreme attention given to details so that a good foundation is laid for the superstructure. The methods of mulberry plantation are generally classified under four heads :—

1. Bush Plantation.
2. Dwarf Plantation.
3. Pollarded trees, similar to France.
4. Full-grown trees.

Each of them is scientifically and methodically adopted and mulberry diseases are carefully dealt with.

V. French Indo-China.

We spent a week in French Indo-China, calling at the ports of Haiphong and Saigon. Saigon is the capital of French Indo-China, and we had here the good fortune to obtain advice and information from the Director of Agriculture and Commerce, who is a keen enthusiast upon the subject.

It is extremely interesting to notice the policy pursued by the French Government in French Indo-China, and the changes which have been made by them as a result of their experience.

As might naturally be expected, they commenced by introducing the French univoltine silkworm, but found that in the warm climate of the tropics it suffered considerably. Attempts were made to cross it with the indigenous worm. These again did not prove very satisfactory. Finally Government Experts decided to devote themselves to the improvement of the indigenous polyvoltine silkworm, which is practically the same as the Canton and Mysore varieties. Here they have achieved great success.

They have devoted themselves to two points: one, the provision of disease-free eggs for the people. For this purpose small inexpensive rearing centres have been established in different parts of the country, and the disease-free eggs issued without charge by Government to rearers. No less than 6,272,500 layings of eggs were issued by Government to the rearers in 1914, and the demand for these eggs was double what Government was able to supply.

At the same time Government devoted themselves to the improvement of the indigenous silkworm, not by hybridizing, but by a careful system of selection. It is now a well-established fact amongst silkworm-rearers that the hybridizing of a well-established nationality of silkworms, if one may use the expression, by another nationality of quite distinct origin, is often unsatisfactory besides being extremely tedious. It is a very slow process, extending over many years, and there is a constant tendency to lapse. Where eggs have to be produced by millions, hybridizing can only work very slowly, and whilst there are many excellent breeds of worms in existence, it is doubtful whether commercially the thing is worth much time, trouble or expense. It ought to be done on a small scale for experimental purposes at Government Experimental Stations, but it should not be regarded as part of the Government commercial propaganda, seeing that the market requires large quantities of raw silk of *uniform* texture, not a hodge-podge of many varieties. This is an important point.

The French Government having devoted themselves to improving the existing indigenous worm, they have so far succeeded that the actual quality and length of fibre produced from some of these indigenous worms thus carefully treated, is almost equal to that of the best French varieties. This is undoubtedly a great triumph, but we may say that commercially it does not at present count for much, and it will be many years before it really makes a considerable difference. The fact, however, that this is being done with the indigenous worm and not with a hybridized lapsable variety is very much in its favour, and points very strongly to the policy which ought to be adopted by Government in India.

It must be remembered that all the prejudice of the French experts must have been in favour of their own very superior French silkworms, and that it has been only with reluctance, and gradually, that they have altered their policy to suit the tropical conditions of the Orient. The Director has a small silk school under his personal supervision in the Botanical Gardens at Saigon, and very kindly showed us all the details of it. Comparing this school with those of the Salvation Army in India, we could not help feeling gratified to find that it was being carried on along almost exactly the same lines as we had ourselves introduced. The whole object was to encourage sericulture, including reeling and weaving, *as a cottage industry*. There was nothing there which a native could not introduce into his own cottage, and yet every implement used was being improved. There was, for instance, very ingenious, simple, and inexpensive system for the silkworms to "mount" when forming their cocoons. This was to take the place of the ordinary *chandrika*, which is there employed very much as in India. There was also a very simple oven for drying the cocoons, the damp climate of the country making it difficult to do this by means of the sun, as is commonly done in India. The system was also much more satisfactory and quite cheap. The professor preferred the dry heat system to the use of steam. The "bassine à feu vu" for cottage reeling was not in our opinion nearly as good as our own Salvation Army Cottage Reeling Machine, nor was the cottage handloom to be compared with ours.

There was a mulberry garden in which different kinds of Tonkinese and Chinese mulberries were being grown, and careful experiments were being tried.

One of the points on which we made careful enquiry during our visit to the East, including China, Japan and French Indo-China, was the possibility of rearing multivoltine silkworms in tropical climates and in the plains similar to Madras, Bengal, etc., practically all the year round. It was quite evident that the indigenous multivoltine could be thus grown if proper arrangements were made for their food. We came to the conclusion that the success in this respect was largely due to the extreme care given to supplying the worms

with juicy leaves from irrigated mulberries, and that a good many failures in tropical climates are due to the fact that the worms have been badly fed and cared for, and that the proper conditions have not been sufficiently watched, while there has been no attempt anywhere made to cope with disease, which, as is well known, is of an extremely virulent character if not checked at the outset.

SCIENTIFIC PLANT BREEDING.*

So much attention has been directed to the purely scientific advance that has followed the birth of Genetics as a new branch of science that little regard has been paid to the very remarkable results already reached by the application of Mendelian methods to the problems of economic plant production. It is necessary to distinguish somewhat sharply between the facts which Mendel was the first to discover, and the hypotheses which have been put forward to explain these facts. The practical plant breeder is not primarily concerned with the theory of the subject; the Mendelian fact of grand importance to him is that unit characters do segregate, and that new combinations of these characters can be made.

It may be of interest, therefore, to consider some of the more important results obtained in regard to food-producing plants, and to indicate some of the difficulties which may impede future progress. Of food grains none is more important than wheat. The most marked achievement in wheat breeding is the production of a variety resistant, if not entirely immune, to the fungous disease known as Yellow Rust (*Puccinia glumarum*), as a result of the discovery that resistance to this disease obeys the Mendelian law of segregation. Once this was established it became a comparatively simple matter to transfer this character as an independent unit from the poor yielding Russian wheat "Ghirka," in which it was found, to a wheat suitable to the conditions of England. The variety "Little Joss," which was "made" in this way some ten years ago, is now well established in the Eastern Counties.

The possible economic value of this achievement becomes apparent if the enormous yearly losses caused by rust—perhaps not far short of 10 per cent. of the yield annually—are considered.

* Reprinted from *Nature*, dated 25th July, 1918.

Another economic character that can be controlled in the same way is stiffness of straw, a matter of importance in those parts of the country, such as the Fens, where a weak-strawed wheat becomes "laid" in wet seasons. It is interesting to learn that a short, stiff-strawed variety known as "Fenman" has recently been produced which is likely to be largely adopted in the Fen country. But the possibility of greater additions to the food supply of the country is now in sight. It is well known that wheat is commonly a slow-growing plant; sown in late autumn or winter, it is harvested in August. Barley and oats, on the other hand, come to maturity more rapidly, and need not be sown until spring. There are, however, certain varieties of wheat which can be sown in spring, but, unfortunately, their yield of grain is considerably less than that given by winter wheats. The result has been that under the ordinary conditions of farming in this country the area that can be sown with wheat is limited to that not occupied by a crop during winter. Barley and oats must be grown after "roots" because the latter are not completely off the ground until early spring. If, then, it were possible to make a spring wheat combining the character of early maturity with a yield approaching that given by winter wheat, the economic gain might be enormous, for, obviously it would be in the interest of home food production to curtail the area occupied annually by barley. If, then, we could add to the existing acreage sown annually with wheat only one quarter of the normal acreage under barley and oats, we should add probably 20 per cent. to the home-grown cereals available for human food. The possibility of making an improved spring wheat depends upon how far early maturity and yielding capacity are found to segregate. Apparently, there are indications that the former does, but the problem in regard to the latter is complex, depending for its solution on the clearing up of the difficulties that are encountered in dealing with quantitative characters, such as yield, as distinct from qualitative characters, such as colour of grain.

The questions involved are obviously of great economic importance, for it is the quantitative characters that often determine the economic value of a plant or animal. But it is not simply a

question of the universality of the Mendelian law. If, as some geneticists hold, the inheritance of quantitative characters is regulated by a complex of unit characters, the practical application of Mendelian principles becomes exceedingly difficult, for with any number of characters over three the number of possible combination of unit characters becomes generally too large to handle. And the difficulty does not end there, for, owing to environmental fluctuation, the comparative genetic behaviour of individuals cannot be disentangled, and the plant breeder is consequently driven to resort to purely empirical methods of selection. Nevertheless the fact that the exact nature of the laws regulating the inheritance of quantitative characters is still obscure may not seriously impede the work of the practical breeder. In fact, it has been found in practice that, provided desirable qualitative characters can be built up in the desired complex, the quantitative characters may be susceptible of improvement by selective methods of a more or less empirical nature.

But when all is said, scientific plant improvement in Great Britain has made only a small beginning, due, no doubt, in part to the general excellence of the varieties of economic plants now established in this country. The "Improvers" of agriculture and horticulture in the nineteenth century revolutionized the industry, and, as an outcome of their activities and influence, British seedsmen, largely by selective methods, effected very great improvements in economic plants. It is only comparatively recently that this country has fallen behind. Allusion may be made to the great advances achieved in Sweden as a result of the work of the Svälof plant breeding station. Denmark also is forging ahead, but, curiously enough, progress has not been remarkable in Germany, owing, perhaps, to the extraordinary cult of Darwinism which prevails there, and the consequent belief in the effectiveness of mass selection. In America considerable progress has been made from a scientific as well as from an economic point of view—notably in producing a cotton immune to the destructive wilt disease.

But if a striking object lesson of the successful application of new methods to plant production is needed, we must turn to

India.[1] Dating from the foundation of the Pusa Research Institute about the beginning of the present century, great developments in the scientific exploitation of Indian agriculture have taken place. Much credit is due to Lord Curzon, who, aided, it is now curious to recall, by the munificent bequest of an American (Mr. Phipps), founded a department which, it is no exaggeration to say, has added thousands, and will add millions, to the wealth of the country. India undoubtedly presented a fine field for the modern plant breeder. If we consider the immense variety of her plant products, their value either as food or in the arts and industries, and then observe that, owing to the absence of any skilled seed production industry, there is an uncounted number of identifiable races within each distinctive variety of economic plant, we can form some conception of the possibilities which even selection presents: superadding hybridization, it is difficult to assign any limits to the field that is opening out.

It would be impossible in the ordinary limits of space to give a detailed account of what has already been achieved, but some indication may be given of proved successes in relation to the more important economic plants.

Mention may first be made of wheat, of which upwards of 30 million acres are grown, and which was naturally one of the first crops to receive attention. Both selection and hybridization have been brought into action, and several new varieties are now firmly established. In the United Provinces in 1917 alone "Pusa No. 12" occupied 100,000 acres, and was extensively grown in the Punjab as well. This wheat gives a cultivator an *increased yield of 25 per cent.* over the varieties formerly grown by him, as well as nearly one shilling per quarter more on the market, owing to its improved quality. Another and later production of Pusa has on occasions given a yield of nearly fifty-five bushels per acre, which for India is an unheard-of figure, and may be compared with thirty-two bushels, the British average yield of wheat. In the Punjab another

[1] Report on the Progress of Agriculture in India for 1916-17. (Calcutta: Supdt. Govt. Printing, India, 1918.)

new variety occupied 97,000 acres, and it is estimated that the growers of this wheat were presented with an additional income of nearly 15,000*l*. In the Central Provinces improved varieties, returning to the cultivators considerably increased profits, occupied 200,000 acres. Remarkable progress is also being made in the production of improved varieties of rice, the most important cereal crop in India. A variety known as "Indrasail," isolated by pure line selection, occupied 20,000 acres in Bengal. In the Central Provinces it has been necessary to establish thirty seed farms for the production of other new varieties. Turning to non-food products, we find that extraordinary advances have been made in regard to cotton (of which 20 million acres are grown in India). In Surat an improved cotton has been produced giving a premium value of 13 per cent.; in Sind new varieties are giving a premium of 23 per cent. In the Central Provinces a new introduction is estimated to occupy no less than 800,000 acres, and to have brought the cultivators increased profits of nearly 900,000*l*. After this we may pass over such relatively inconsiderable figures as 215,000 acres under a new variety in the Punjab, but, for its human interest, mention may be made of one incident in a campaign directed to the eradication from a certain district of an inferior indigenous variety. It is a good example of the methods adopted to impress the Oriental imagination. "In the Tinnevelly District the department had to resort to drastic action for the control of seed in the case of some ninety acres of *pulichai* (the inferior cotton)......the seed from this cotton was publicly burnt......before a large gathering of ryots."

In the improvement of jute (of which India exports annually products worth £40,000,000) some notable advances have been made. It is expected that in the present year more than 30,000 acres will be sown with a new selected variety as a result of the distribution by the department of 500,000 packets of seed. In this connection a valuable scientific discovery may be mentioned. The pernicious weed, water hyacinth, which infests the waterways of Bengal, has been found to have a high potash content, and is consequently a valuable manure for jute, the use of which not only directly

stimulates yield, but also protects the plant against a *Rhizoctonia* disease which attacks it.

It will be readily admitted that this tale of economic progress is astonishing. No mention has been made of the purely scientific results achieved, and they are very considerable. The workers no doubt feel well rewarded by the satisfaction with which they must regard the additions to knowledge which they have made, but they may also feel some pride in the remarkable economic advances which their labours have brought about, especially in regard to the food-producing plants.

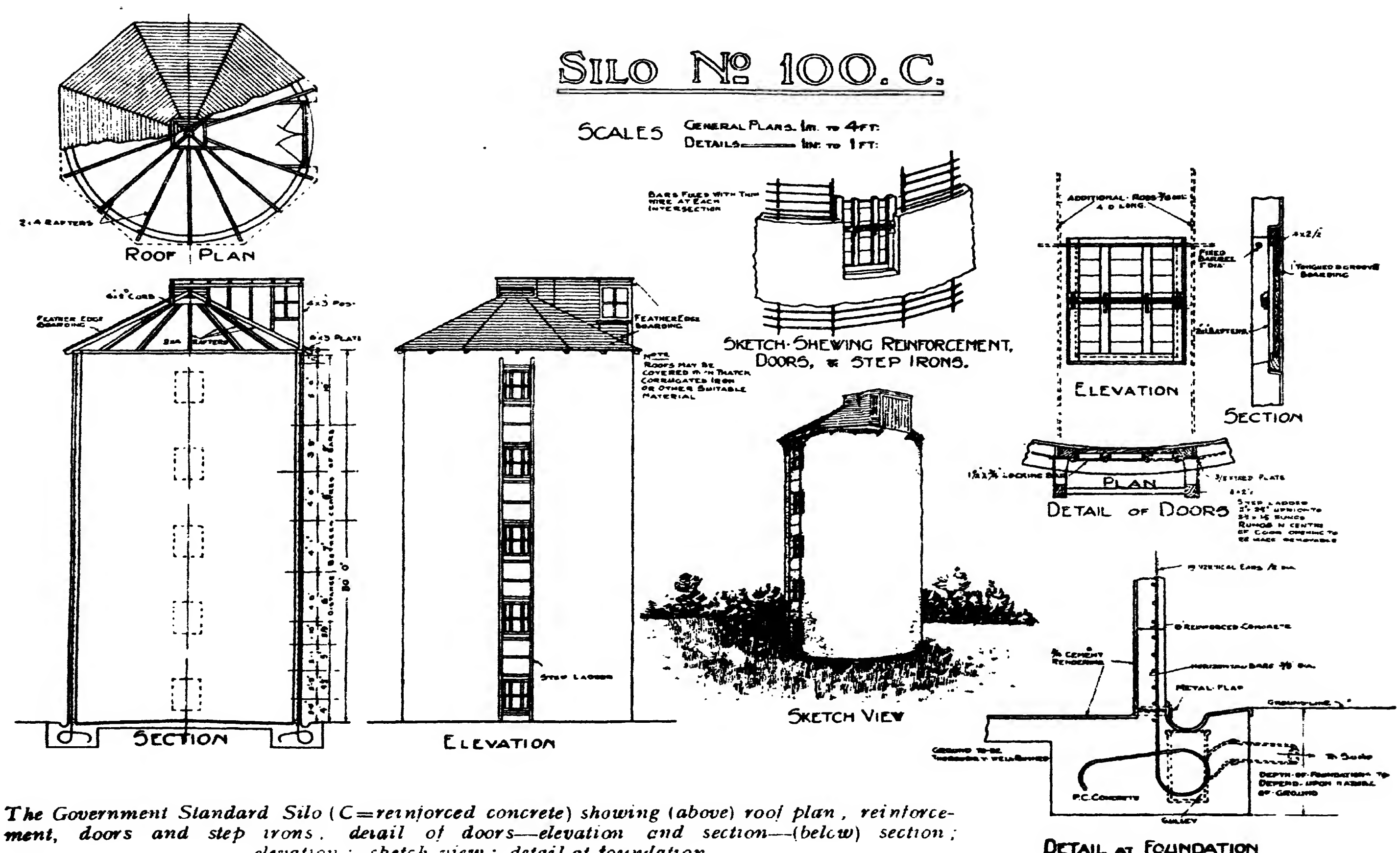
THE GOVERNMENT'S STANDARD SILO.*

Early in the present year (1918), on January 12th to be exact, we published a leading article dealing with the need for ensilage that must ensue from the conversion of so much pasture land into arable. Apparently it hit the nail on the head. There followed much interesting correspondence from those directly interested in this method of preserving summer herbage for winter food. Incidentally it disclosed great differences of practice and opinion. On one point alone was there unanimity. Every practical stock-owner felt that, as the contraction of grazing space synchronized with a serious and increasing scarcity and dearness of feeding stuffs, the silo must now enter on a new career of usefulness. Previously it had been the custom to discount its free use in Canada and the United States by pointing out that in these countries the length and severity of the winter compelled farmers to stable their livestock and feed indoors for a larger portion of the year than is necessary with us. But the circumstances arising out of the war caused them to drop this excuse for indifference. It was disclosed that to a greater extent than had been generally known those farmers who recognized that agricultural success depends upon taking long views had been quietly preparing to make ensilage. Enquiry on our part showed that the movement had been most pronounced in the Eastern Counties, where the root crop is very uncertain, and that Mr. Amos, whose successful management of the Downing College land is very well known, had given special attention to the subject. Fortunately, we were able to induce him to write a series of articles that proved to be valuable and instructive.

Meanwhile, the Board of Agriculture, through its Food Production Branch, had taken the matter up seriously. Previously the

* Reprinted from *Country Life*, dated 18th May, 1918.

PLATE II.



The Government Standard Silo (*C=reinforced concrete*) *showing* (*above*) *roof plan, reinforcement, doors and step irons. detail of doors—elevation and section—*(*below*) *section; elevation; sketch view; detail at foundation*

subject, without being ignored, had from time to time been agitated, but not in a manner that attracted much attention. At any rate, no successful attempt had been made to get silos erected on British farms. From time to time official articles had been published, calling attention, indeed, to the advantages of making ensilage and giving instructions how to set about it, but altogether lacking in workable proposals for translating academical teaching into the general practice of husbandry. But the question was now tackled in a more purposeful spirit. An expert was engaged to visit and report upon silos in actual operation. Conferences were held to compare and estimate the relative advantages of different types, and finally standard plans were drawn up and are now made available for all who wish to erect silos of their own (Plate II). They will be disseminated by a machinery originally produced to deal with war agriculture. In other words, the County Executive Committees are called upon to promote the object in view. Plans and specifications are to be placed on view in the offices of each Committee, open to inspection by all who are interested. Also a little pamphlet has been drawn up for distribution. This clear and concise document should prove most serviceable. Standing alone on the first page is the sketch of a reinforced concrete silo for one hundred tons, and on the next a corresponding sketch of the reinforced brick silo for holding fifty tons—the former suitable for a herd of twenty-five cows, and the latter for a herd of twelve cows. Then follow the terms of the offer made by the Department, which are five in number, and are offers of (1) expert advice; (2) free supply of full working quantities, drawings and specifications; (3) loan of form and centering (moulds) and facilitating use of permit for materials; (4) estimating for complete construction of silos at a fixed price; and (5) assisting with any type of size other than the standard one adopted.

In considering this very encouraging offer, it would be well, in our opinion, to keep two considerations in mind. Whatever arguments may be advanced in favour of a wooden in preference to a concrete or brick silo, do not affect the difficulty of obtaining the timber with which to build it. That is a difficulty which apparently has decided the Department to say nothing about this type of silo.

Again, a very large number of our correspondents wrote with admiration of the rough-and-ready stack silo which in many cases has been enough to serve the purposes of the holding. Now, a stack silo is better than none, and in these times a man often has to consider less what he would like than what he has at disposal. Therefore it would be wrong to discountenance any method of increasing the home-grown and home-preserved food for livestock. But the stack silo is very uneconomical for permanent purposes—it is attended by a too serious decrease in solids. Two very useful sizes have been chosen, one 15 ft. in diameter by 30 ft. in height, capacity 5,300 cubic feet, holding about 100 tons of ensilage. The other is 24 ft. in diameter by 24 ft. in height, with exactly half the capacity of the other. Each type can be built either in reinforced brick or reinforced concrete.

We must not omit some reference to the last page, which is filled with a table of advantages of silage, very tersely and clearly put, each point being a maxim in a nutshell. The first four refer to it being a means of preserving green fodder for the winter, being independent of weather, being more certain on heavy clay land than root crops, and being cheaper than root growing under unfavourable conditions. The next two are directed to the growing of silage as a catch crop or a cleaning crop; the last four relating to the economy of labour and time which is secured by the use of the silo. They form an excellent set of precepts, well fitted for their purpose, which is the dissemination among those who are in any way likely to wish to build a silo for their own use.

We have no doubt that the number of those who wish to do so will exceed what is possible this year, owing to the difficulties connected with labour and material. Every stock breeder, and especially the cattle breeder, will find that under the new system of agriculture now inaugurated and not likely to be given up or even to be radically changed in our time, the silo will be an indispensable adjunct to the farm.

AN IMPROVED TYPE OF COTTON FOR THE SOUTHERN MARATHA COUNTRY.

BY

G. L. KOTTUR,

Cotton Supervisor, Southern Division, Bombay Presidency.

COTTON is the most important crop in the black soil tract of the Southern Maratha Country, and covers an area of one to one and a half million acres in the districts of Dharwar, Belgaum, and Bijapur of the Bombay Presidency. The adjoining cotton-growing areas in the Madras Presidency and in the Native States of Kolhapur, Miraj, Sangli, Hyderabad, and Mysore present similar physical features and grow the same variety of cotton. The problems for solution in connection with cotton are therefore the same for the whole of this tract.

Except for a comparatively small area under Dharwar-American cotton, the whole of this tract grows a variety of *Gossypium herbaceum*, known in the local vernacular as *jowari-hatti*. It is botanically identical with Broach cotton, but agriculturally it differs in many points. It is a late sown cotton producing seedy *kapas* only one-fourth part of which is lint. The latter reaches the spinners under the name of Kumpta cotton. It is suited to spin 30's, and therefore ranks high in the list of long-staple *desi* cottons. We have in India few long-staple cottons, and the few that we have are in danger of being ousted by short-staple varieties. In the Southern Maratha Country, however, conditions are unfavourable to the growth of short-stapled varieties, and the tract is recognized as essentially a long-staple tract. Many other long-stapled cottons, both Indian and exotic, were tried in Dharwar, but

without producing any sustained success, and the only cotton brought from outside the tract that has survived the ordeal is the Broach cotton grown from Navasari seed, which has established itself in a limited area where conditions are favourable, and is still grown to the extent of a few thousand acres. Cross-fertilization also was tried, but out of a large number of hybrid cottons produced almost all have been finally discarded as unsuitable, and none has yet been regarded as suitable for introduction. Selection from the local variety was therefore the only method left by which improvement might be secured.

Now what are the characteristics of the local cotton (*jowari-katti*)? It is sown in August-September, and is ready for the first picking by February-March. It is a stunted plant with a small average outturn of *kapas* per acre and a low ginning percentage (25%). The average outturn of *kapas* is taken at 320 lb. per acre, giving 80 lb. of lint. The staple, though long, is uneven and often weak. These defects gave an indication as to the directions in which improvement was indicated.

All *herbaceum* cottons produce a number of extra-axillary vegetative branches or limbs from the lower portion of the central stalk. These limbs take off from the main stalk at an angle of 45° and function exactly like the main stalk. At each node above the limbs, the main stalk bears two kinds of branches—(1) extra-axillary or fruiting, and (2) axillary or vegetative. The fruiting branch takes off at right angles from the central stalk, and at each node it slightly changes its direction of growth and produces a pedicel bearing a solitary flower. The vegetative branch behaves like the limbs, takes off at an angle of 45°, grows straight, and directly bears no fruits, but produces secondary fruiting branches. Now a study of the local cotton shows that there are two distinct types to be found, the erect type and the bushy type (Plate III). The erect type is characterized by the meagre development of limbs and vegetative branches. It grows tall and from each node produces a prominent fruiting branch. The bushy type, on the contrary, has from 5 to 10 limbs, and of its branches it is the vegetative ones that are prominent and vigorous, while the fruiting branches on the main stalk

PLATE III.

Erect type Bushy type

Diagrammatic representation of the two types of *Jowari-hatti* cotton.
L - limb; F - fruiting branch; A - axillary branch.

are mostly suppressed and insignificant. In each case these characteristics are hereditary. The economic significance of this differentiation lies in the fact that it is the fruiting branches on the main stalk which first bear fruit, next the limbs, and last of all the vegetative branches. This difference would be immaterial if the environment were equally favourable to the reproductive activity of a plant throughout its growing period. But such uniformity is not obtained, for in the months of February and March there is a marked tendency for the late flowers to fall off. To secure yield, therefore, it is necessary to select the early flowering plants, that is to say, the erect type. Continued field tests have shown the superiority in yield of this erect type, and by sustained unit selection we have now got a plant which yields 12 per cent. more *kapas* than the local cotton; a *kapas* which yields 12 per cent. more lint than the local *kapas*, and lint which is valued at 5 per cent. more than the best Kumpta cotton available in the market.

The following report of Messrs. Forbes, Campbell & Co., of the Gokak mills, who kindly made the spinning test of our cotton, testifies its importance in the spinning industry of the future :—

"The cotton was considerably superior to any of the Kumpta cottons as supplied either direct or by the ryots or which we have obtained from the near markets. It is bright, light, clean, long in staple and uniform, and of middling strength. From it we spun three counts, *viz.*, 20's, 30's, 40's. The yarn ran smoothly and demanded very little attention from the work people, and we would no doubt have received better results, had we had sufficient cotton to make it worth our while to alter our machinery, so that it would be spun into yarn under the best conditions."

It is proposed to multiply and distribute seed of this improved type, and it is believed that by this means the economic condition of the cotton-growers will be materially improved and the spinning value of the Kumpta cotton will be enhanced.

CO-OPERATIVE SOCIETIES AND MARKETING OF COTTON *

BY

THE HON'BLE MR. PURSHOTAMDAS THAKURDAS, M.B.E.

IT is very usual to hear people swearing at cotton merchants on the ground that they buy *kapas* (unginned cotton) from cultivators very cheap and generally buy it before it is ripe to be marketed. In my written evidence to the Indian Cotton Committee I said as follows on the score of the cultivators' agency for marketing of *kapas* in the districts and on the score of the system of advances :—

" Regarding the system of the cultivators' agency for marketing of *kapas* in the districts, this also varies in various districts. The intelligent cultivator of the Surat and Broach districts does not, as a rule, employ an agent to sell or market his *kapas*. If he does not or cannot sell his *kapas* from his residence, he markets it himself and sells it off to the highest bidder on that day. He recovers the cash for it immediately. On the other hand, the ryot of the United Provinces or Khandesh sends his *kapas* to his *aratiya*, or commission agent, for sale and pays him a commission for the same. These *aratiyas*, wherever they are influential and wealthy, are *aratiyas* or commission agents for buyers also, and this dual capacity of theirs exposes them to a considerable temptation.

" *System of advances*. The system of advances to cultivators on their *kapas* divides itself into two chief parts.

" The first is advances against standing crops before the crops are matured and the other is advances against actual *kapas* when marketed. Regarding the first, this system is generally known as *jalap* and means the ryot estimating the outturn from his field and selling the same to the *sowkar* (money-lender) at a rate equivalent

* A paper read at the Co-operative Conference held at Bombay in April 1918.

to anything from Rs. 30 to Rs. 100 per *candy* (784 lb.) of cotton lower than the rate prevailing in Bombay. Against this sale the *sowkar* advances him 50 to 100 per cent. of the cost of the *kapas* so bought. The risk of such a buyer is twofold. Firstly, the risk of unforeseen ruin of the crop quantitatively, and, secondly, the risk of unforeseen damage to the quality of the crop by untimely rain or frost. This system was very prevalent twenty years back. The Deccan Agriculturists' Relief Act considerably discouraged this practice, but it still prevails to a fair extent.

"There is a good deal to be said against this practice of *jalap*. But in recent years when the prices of cotton may be said to have broken records of anything up to the last fifty years, the ryots themselves have shown great anxiety to avail themselves of rates which appear to them to be very high. All that could be suggested on this score is that co-operative credit societies should undertake what the village *sowkar* does, and should retain the margin for themselves in exchange for the risk that *jalap* operations entail on the buyer. As a matter of fact, I have not yet been able to comprehend why the various co-operative credit societies have not done so till now in their districts.

"The second mode of advances is the ordinary method of advances against *kapas* brought to the market, and I am not aware of any particular disadvantage to the ryot in this."

It will be perceived that as long as the Indian cultivator continues to be in a position where he must have money before the crop is ripe to be marketed in the normal course, some sort of accommodation is necessary for him. It need not be doubted that the *sowkar* giving him this accommodation makes the best of his opportunity to exact terms compatible with the risk he runs in making advances to the cultivator. I wish to suggest that people interested in the co-operative movement should turn their attention to replacing the *sowkar* or the cotton merchant with co-operative credit societies. It is well known that these advances to cultivators have to be made in the months of July to November when money is fairly easy everywhere, and it is not likely that co-operative credit societies will find any difficulty in securing money. What would be very necessary

to have is persons well-versed in cotton business to ensure that the co-operative credit societies' selling of cotton against a cultivator's *jalap* sale of *kapas* fetches the highest rate available either in that district or in Bombay with smallest risk regarding class, etc., to the seller. When this is organized it would mean that the cultivator selling his *kapas* would get that day's fullest market rate, and he would only have to pay interest until his *kapas* is actually delivered to the buyer. So much for improvement that can be effected in the cultivators' more or less necessary method of selling his crop before maturing.

Regarding the first paragraph of the quotation from my evidence given above, I think that even when crops are marketed after maturing, it is very necessary in some of the cotton-producing districts in India to have a co-operative credit society's agency for each day's *kapas* arrivals in each market. If this be organized with the help of reliable men on the staff of such agencies a lot of annoyance and petty losses to cultivators can be avoided, and looking to the increasing acreage under cotton all over India it would appear most necessary to organize such selling agencies in some of the important districts at least where there are no proper arrangements for independent weighment, etc., of the cultivators' produce. A good deal is being heard this year from well-meaning people not intimate with conditions and customs of the cotton trade regarding cotton merchants looting the cultivators. I have seen handbills asking cultivators in the district not to deliver *kapas* against their comparatively lower rate sales.

This is not the place to discuss the advisability or otherwise of such recommendations to cultivators, but this surely is the time to organize some sort of agency to keep cotton cultivators in good touch with the course of the cotton market in Bombay and abroad.

SUGAR AS A COAGULANT FOR *HEVEA* LATEX.*

BY

RUDOLPH D. ANSTEAD, M.A.,

Deputy Director of Agriculture, Planting Districts.

EATON and Grantham[1] found that if *Hevea* latex is allowed to stand in tall cylinders without the addition of any coagulant a slimy alkaline surface scum is formed, whilst the lower layers become acid and coagulation occurs in them. The surface changes are putrefactive in character and are brought about by organisms which are favoured by aerobic conditions.

The changes in the deeper parts of the liquid were considered by the authors to be due to activity of aerobic organisms. Both classes of bacteria were supposed to infect the latex after collection from the trees.

Whitby and Campbell showed that coagulation is not due to bacteria but to an enzyme, but that the putrefactive changes are due to bacteria, which by producing an alkaline medium, may destroy the enzyme and arrest coagulation in favour of putrefaction. Barrowcliff[2] brought forward a large amount of evidence to support this theory of coagulation and show that it was due to a specific enzyme.

In order to eliminate to some extent the predominance of the putrefactive changes and encourage the non-putrefactive ones, cane sugar and glucose were added to latex, and it was found that with each of these complete coagulation was obtained and

* Reprinted from the *Planters' Chronicle*, dated 10th August, 1918.

[1] Eaton and Grantham. *Agri. Bull., F. M. S.*, IV, 2 (1915). *India Rubber Journal*, LI, 10, p. 340.

[2] Barrowcliff. *Jour. Soc. Chemical Industry*, XXXVII, 3, p. 48T.

putrefactive changes were inhibited. With pure crystalline dextrose it was found that as small a quantity as 0·2 per cent. calculated on the latex, was sufficient to bring about complete coagulation within 18 hours, and this coagulation took place most readily in closed vessels filled with latex so as to exclude the presence of air. The dextrose was completely decomposed and the coagulum was full of bubbles of carbon dioxide. Similar results were obtained with cane sugar, lactose, arabinose, mannose, and lævulose.

Subsequent experiments showed that if the temperature was kept low, below 40° to 50°F., coagulation was inhibited, but if the temperature was allowed to rise to 84°F. coagulation became complete.

At a time when there was a shortage of acetic acid it was suggested in the F. M. S. that cane sugar might be used as a substitute. A number of experiments were carried out in Java and the result of trials made at the Central Rubber Station for testing was that the difference between rubber coagulated by acetic acid and that coagulated by sugar were insignificant.[1] Tensile strength, slope and viscosity are nearly always the same, but in the rate of cure a small difference is generally found, the sugar coagulated rubber curing slower or quicker as the case may be.[2]

This means that with a running sale contract the change from acetic acid to sugar would nearly always mean a change in the rubber delivered which, unless warning was given, must be considered undesirable.

On this point Dr. O. de Vries[3] issues a word of warning, namely, not to change the coagulant before being convinced that it will not change the quality of the product. He points out that a new coagulant may often influence the rate of cure and so inflict serious losses on manufacturers and again awake their former distrust of plantation rubber. Manufacturers are now accustomed to certain characteristics in plantation rubber and have arranged

[1] Gorter and Swart. "Mededeelingen Rubber proefstation West Java, 6." *Agri. Bull., F. M. S.*, V (1916), p. 48.

[2] *Monthly Bulletin of Agri. Intelligence*, Rome, VIII, 10 (1917), p. 1421.

[3] *India Rubber Journal*, LII, 21, p. 744.

their treatment accordingly. A change in these characteristics without warning would be the cause of great trouble to them. A conservative policy is therefore advised by de Vries, who thinks that no change should be made before the peculiarities of the new coagulant have been thoroughly investigated. Every planter's ideal should be to sell his rubber under his own trade mark, by preference to one and the same buyer. This would be the surest way to fetch the highest prices and to obtain the best market. It will be obvious that such a customer would not be at all pleased at receiving unexpectedly a lot of rubber of different quality.

In general, however, and for the open market, the small difference in rate of cure can form no objection to sugar coagulated rubber. The difference is well within the limits which are generally found for ordinary first latex crepe. In three series of experiments the uniformity from day to day was not less with sugar coagulation than with the ordinary acetic acid coagulation.

The advantages and disadvantages of sugar as a coagulant may be summed up as follows:—

The great advantage is the cheapness of the material as compared with acetic acid, especially at the present time, while moreover it is always available in the country and does not depend upon shipping facilities. The quantity required is very small, 0·1 to 0·2 per cent. of sugar calculated on the latex, or one part of sugar to 500 parts of latex.

The disadvantages are first of all that it produces a product which differs slightly in rate of cure from acetic acid coagulated rubber, necessitating in the case of contracts a warning of the change to the buyers.

Another objection is that the coagulum is apt to be full of gas bubbles due to the evolution of carbon dioxide during the coagulation process, and sheet rubber suffering from this defect is looked on with disfavour in the market although the actual quality of the rubber is not affected by the presence of the bubbles. If crepe is being made, the bubbles of course do not matter, but sheet is chiefly made now.

Probably any drastic change in methods of coagulation likely to be adopted in the near future will tend towards what is known

as the M. C. T. process in which no coagulant is used at all, and by means of which a standard rubber can be made whatever the source of the latex.[1]

This process is based on the fact that in *closed vessels* latex coagulates completely without the addition of any coagulant and without putrefactive changes taking place. As carried out in practice, large cement tanks, provided with heavy water sealed lids, are used. Into these the bulked latex is poured, leaving the smallest possible air space above it. To each 100 gallons of latex, a quantity of calcium acetate equivalent to 4 oz. of calcium may be added if desired to accelerate the process. The covers are placed in position and sealed, and the whole is left undisturbed for three days when coagulation is complete. The resulting coagulum is converted into crepe in the usual way.

For the manufacture of sheet, iron pressure vessels are used, divided into partitions with aluminium sheets, and the coagulation takes place under a pressure of one or two atmospheres, which keeps the carbon dioxide evolved in the process in solution, and the resulting coagulum is free from bubbles and can be made into sheet.

[1] Barrowcliff. *Jour. Soc. Chemical Industry,* XXXVII, 6, p. 95T.

Notes.

SELECTED CAWNPORE-AMERICAN COTTONS AND THEIR COMMERCIAL VALUATIONS.

In a previous number of this Journal[1] it was stated that, while Cawnpore-American cotton, as it then existed as a field crop, yielded well under irrigation and produced a cotton which found a ready market, there existed a considerable margin for improvement by selection in regard to yield, ginning percentage and uniformity of staple. The isolation of pure races was therefore taken up in 1912. Progress reports on this work have been given in the annual reports of the Cawnpore Experiment Station, and the detailed results are being published separately. As, however, a certain measure of success has been attained it may be of interest to summarize the main features here.

In 1912 a number of different types of Cawnpore-American cotton were selected from the field crop, selfed seed obtained (cross fertilization being prevented by covering the plants with mosquito nets), and the resulting progeny studied through several generations —with the necessary precautions to prevent crossing. In this way a number of races were obtained differing considerably in agricultural characters, in ginning percentage, and in lint. A large number of these races were discarded in the course of this work on account of unsatisfactory lint, low ginning percentage, excessive length of vegetative period, imperfectly hairy leaf (and consequent susceptibility to attack by aphis with the subsequent "red leaf" damage) or unsuitable habit. By 1916 a series of likely races had been obtained which were then tested for yield and ginning percentage on a field scale and for which, through the courtesy of Messrs. Tata & Sons, we were able to obtain commercial valuations of the cotton which were of the greatest value in deciding what types to retain.

[1] *The Agricultural Journal of India*, vol. VIII, pt. IV, 1913.

Through the kindness of Mr. Hodgkinson of the Indian Cotton Committee, arrangements were made for the valuing of several of these cottons, from the 1917 crop, in England, and the report of the expert brokers to the British Cotton Growing Association is as follows:—

Per lb.

"Ca 1 22·00 *d*. Good colour, about good middling in grade, staple 1 to $1\frac{1}{16}''$. Rather mixed.

"Ca 5 21·50 *d*. Rather dull, barely good middling, $\frac{7}{8}''$ to $1''$ staple.

"Ca 7 24·50 *d*. Good middling, strong and silky, staple $1\frac{1}{8}$."

"Ca 9 24·50 *d*. Good ,, strong and silky, staple $1\frac{1}{8}$."

"Ca 11 21·50 *d*. Good ,, good colour, $1''$ to $1\frac{1}{16}''$ staple.

"Ca 18 24·50 *d*. Good ,, good colour, $1\frac{1}{8}''$ staple.

"Ca 26 23·00 *d*. Good ,, good colour, $1\frac{1}{16}''$ staple.

"All based on July American futures 22·00 *d*. per lb.

"Good middling American 21·56 *d*. ,, ,,

"The Ca 7, 9 and 18 are very good and are cottons which could be used extensively in Lancashire, and if India could produce any quantity, there should be an excellent demand. Of course you will understand that prices are abnormal and that it would not always be possible to obtain a basis of 250 points on for such cotton. Probably 70 to 100 points on would be nearer the mark. No. Ca 26 is also a good cotton, and could be used, but not to the same extent as the others. These qualities are, of course, a great improvement on the samples of Punjab-American 4 F."

As regards the order of merit of the various cottons, this report entirely bears out Messrs. Tata & Sons' valuations.

The British Cotton Growing Association's report on the unselected Cawnpore-American of the 1912 crop, which is reproduced here for convenience, stated as follows:—

"302 Cawnpore (American). Equal to about low middling in grade, rather dull, staple $1\frac{1}{8}''$, silky, strong but irregular."

Not only are the races Ca 7, 9 and 18 superior to the original in grade, which might be due to better handling and ginning, but the staple has been maintained and the irregularity complained of removed.

It may be explained that the other races, though known to be somewhat inferior to the others in staple, were all retained for

special reasons until further field trials had been made. No. 11 is an exceedingly early flowering type, Ca 5 is a very prolific yielder and has a high ginning percentage, whilst Ca 1 is of a larger habit than the others and has yielded exceptionally well in certain years.

The accurate comparison of a series of cottons for yield is necessarily a matter of some years, especially with seasons so variable as are experienced in Cawnpore. The monsoons of 1915-17 were entirely abnormal, rainfall being excessive and cotton yields over the greater part of the province unsatisfactory. Not only did this hamper work by reducing the amount of seed available for the succeeding years' work but the results themselves require confirmation in more favourable years. It can, however, be stated that Ca 7 and Ca 9 (and Ca 5, Ca 11) have given yields well above the average in unfavourable years. Ca 18 may possibly prove unsuitable for Cawnpore owing to its longer vegetative period and late maturing.

In ginning percentage Ca 7 (33 per cent.), Ca 9 (33 per cent.), Ca 5 (34-35 per cent.), and Ca 11 (33 per cent.) are superior to the original field crop (30-31 per cent.).

It has been proved that given an adequate irrigation supply for timely sowing and adequate marketing arrangements Cawnpore-American cotton can be profitably grown around Cawnpore. Among the above-mentioned pure races we have apparently cottons suited to Lancashire requirements. Incidentally, we have generally been able to obtain adequate prices for Cawnpore-American cotton from Cawnpore mills.—[B. C. Burt.]

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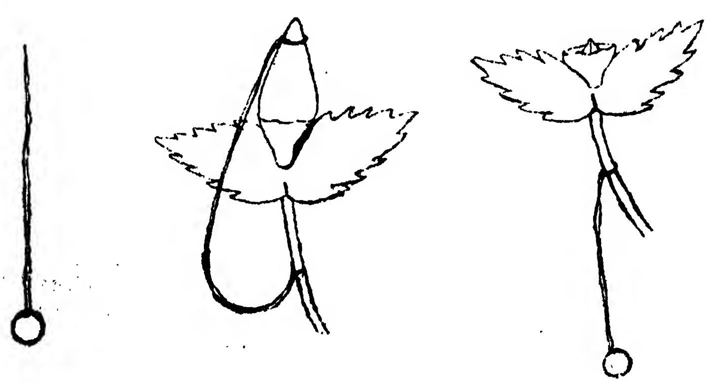
NOTE ON PROTECTING COTTON FLOWERS FROM NATURAL CROSSING.

Natural crossing takes place in all cottons to a greater or less extent, and its seriousness has been demonstrated and admitted in all countries. The Indian varieties cross freely with each other, and when these are grown together in breeding plots or in comparative trials, care is necessary to maintain them pure. For the same reasons all promising strains evolved from single plants must be protected. In fact the danger from natural crossing is so great that every seed allowed to ripen in the usual manner is of doubtful origin.

Natural crossing can be prevented by growing the cottons in bee-proof cages. It may not be, however, possible to provide such cages, and, moreover, they are unnecessary in many cases when only a small quantity of the pure seed is needed. Single plants can be protected by netting; but the netted plants attract the jackals and are damaged by them. They also suffer seriously from the attack of aphis. Under these circumstances, it has been found very convenient to protect a few flowers on every plant required pure for propagation.

The usual method of protecting the flowers is to cover them by means of small paper bags. Bagging presents certain difficulties. The paper used should be strong enough to bear the beating of the surrounding branches, especially when the wind is blowing hard. The tying also should be done carefully, otherwise the bag goes off the flower. The expense and trouble in making the bags and putting them on to the flowers is also considerable. Taking these things into consideration, another method was tried by the writer last year and was found to be very effective. Rings made of thin wire were employed in place of paper bags. These were put on the fully developed buds before they commenced opening. The form of the flower being a cone, there was no difficulty in putting the rings tight, and these prevented altogether the opening of the petals. Further the stalk of the protected flower was marked by a piece of cotton thread attached to the ring. The following figures illustrate the method :—



The method is easy, simple and inexpensive. It therefore claims general application on all farms where the necessity of maintaining the varieties pure is felt.—[G. L. KOTTUR.]

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IN the Kohat District of the North-West Frontier Province, there grows wild the **dwarf-palm** ***(Nannorhops Ritchieans)*** known locally as *mazri*. In one tahsil alone the area occupied is estimated at about 100 square miles, and the total annual production of leaves at about 500,000 maunds or about 8 maunds per acre. Like the coconut palm of the West Coast, *mazri* plays an important part in the economic life of the people of the district, for no portion of it goes without use. Its leaves produce an excellent fibre for preparation of sandals, cordage ropes, floor and roof matting, baskets for household use, punkhas, skullcaps, brooms, etc.; its dry leaves are used for lighting fires and its fruit is eaten. There is also a considerable demand for *mazri* articles in other parts of the Frontier Province and in the Punjab, and in addition to the local production valued at about five lakhs of rupees, *mazri* articles of the aggregate value of Rs. 1,22,203 were imported during 1915-16 from the Kurram Valley, Tirah, and Kabul. As stated above, *mazri* in the Kohat District grows wild and is not cultivated, and the manufacture of fibre articles is carried on in a more or less haphazard manner. In view of the considerable industrial possibilities of the palm, Babu Ram Sarup Dutt, of Kohat, submitted a paper to the Indian Industrial Commission, giving a history of the present condition of the trade in *mazri* and embodying suggestions for its commercial exploitation on a wider basis. He has supplied us with a copy of his paper, and we notice that he suggests the utilization of *mazri* leaves as a substitute for other costly fibres, for manufacture of paper, pasteboard and brushware, and for articles of household use such as chairs, suit cases, hat boxes, meat safes, tiffin baskets, door mats, etc. His suggestions are based on the fact that similar

varieties of dwarf-palm are put to these uses in other countries, but he acknowledges that much investigation is necessary. Considering the backward condition of the province, Babu Ram Sarup suggests that Government should pioneer the industry, and if the experimental factory is found a commercial success, it may be made over to a private body under proper Government control. He believes that there would be no dearth of labour, for the discharged sepoys of the Kohat District will be available in numbers. What interests us specially is the writer's suggestion that experiments may be made as to whether *mazri* can be cultivated as a field crop and that attempts may be made to extend its area. This will naturally follow if the claims made on the industrial side are justified by results, for as Babu Ram Sarup himself says, "once the zemindar comes to realize that the plant is coming to be counted as a plant of great commercial value, he will leave nothing undone to promote its growth." If it is to remain a cottage industry, the sovereign remedy for all its ills lies in Co-operation, to which the energies of the public-spirited people of the district might be usefully directed.—[EDITOR.]

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BY-PRODUCTS OF SUGAR MILLS IN FORMOSA.

SUGAR factories in Formosa generally work for six months in the year, from the middle or end of November to May, though in years of good crop work may extend for seven or eight months, from early in November to the end of May or June. For the rest of the year no work is done other than repairs.

According to information supplied by H. M. Commercial Attaché at Yokohama, the molasses produced is manufactured into alcohol and "Tomitsushu," the latter appearing to be a liquor somewhat similar to rum, and which is used by Formosans. There seems to be but little molasses wasted, though a considerable quantity has been exported to China and Japan or sold locally.

The following table gives the quantity of molasses, alcohol and "rum" (Tomitsushu) in recent years :—

Year	Output of molasses	Quantity used for alcohol	Quantity used for "rum"	Total
	* Kin	Kin	Kin	Kin
1912-13	59,325,018	20,573,360	32,810,810	53,384,170
1913-14	42,951,244	12,619,247	19,418,488	32,037,735
1914-15	37,234,126	22,631,125	17,852,451	40,483,576
1915-16	77,612,097	63,328,048	17,981,514	81,309,598
1916-17	140,478,843	99,461,425	21,546,532	121,007,957

* Kin=1·323 lb. av.

The above figures are supplied by the Bureau of Productive Industries, but it is evident from the totals that considerable quantities of molasses must at times be carried forward to the next year.

There are no special Government regulations controlling or restricting the fermentation of molasses, other than the general law governing the manufacture of saké. The alcohol and "rum" produced are liable to taxation.

No molasses is thrown away. Occasionally when there is a shortage of fuel, molasses may be poured over crushed cane, which is then used as fuel.

At times molasses has been used for cattle food. So far, however, there has been no excess really available as a regular cattle food.

A certain quantity of molasses is exported to Japan and China, to the former by the sugar mills, and to the latter by Formosans.

The quantity of such export in recent years has been as follows :—

Year	Export to Japan	Export to China, etc.	Total
	Kin	Kin	Kin
1912-13	4,443,153	843,931	5,287,084
1913-14	2,559,776	247,687	2,807,463
1914-15	433,360	1,053,429	1,486,789
1915-16	65,290	6,294,095	6,359,385
1916-17	1,650	11,796,668	11,798,318

The manufacture of alcohol and "rum" is not regarded as a by-production of the mills. The business is conducted separately though it is not stated whether separate amounts of capital are allotted to the molasses business. The percentage of production of molasses has been stated to be 27 kin to 100 kin of sugar, and the prices of molasses have fluctuated between 3·30 yen* per kin and 0·40 yen per kin with an average of 0·60 yen to 0·70 yen per kin.—[*The Board of Trade Journal*, dated July 11, 1918.]

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HOME SUPPLIES OF POTASH.

It seems quite probable that the United Kingdom, after the war if not earlier, will be in a position to supply itself with potash, and so become totally independent of German and other sources from which we drew to a very considerable extent in pre-war days. Of course we have no natural potash deposits such as those which exist at Stassfurt in Saxony, and are sufficient to supply the needs of the whole world, but potash is present in many things, and not least in blast furnace dust. As the result of experiments in North Lincolnshire it has been found possible by the addition of a small quantity of common salt to the furnace burden to extract potash in considerable bulk at practically little more than the cost of the salt. With the financial support of the Government a factory has been built and equipped at Oldbury, near Birmingham, capable of an output of 400 to 500 tons of potassium chloride per week, and it is part of the scheme, according to the *Board of Trade Journal*, to erect also a conversion factory, where the chloride not needed for agricultural purposes may be converted into refined potash salts. Other factories in the neighbourhood of blast furnaces in Cleveland and elsewhere are reported to be in contemplation. It is estimated that 50,000 tons per annum could be made available at an economical cost. Great Britain requires now about 30,000 tons of potash fertilizer, besides smaller quantities for the glass, soap, dye, match, and other industries annually. Before the war we imported potash compounds to the value of one and a third

* Yen = 2*s*. 0½*d*. at par.

million pounds (£1,380,567 in 1913), of which 66 per cent. was derived from Germany and the remainder from France, Russia, British India, Belgium, etc. The cessation of imports from Germany created a serious position for England, but the difficulty has been overcome by importing enormously increased quantities of nitrate of potash (saltpetre) from India, and various compounds from elsewhere. The need even for this is now disappearing to some extent, as a result of the development of home production. Germany placed great reliance upon her State-managed potash business, the sales of which in 1913 had a value of over ten millions sterling, and by reason of this had also a practical monopoly of optical glass manufacture.—[*The Economist*, dated September 21, 1918.]

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THE PRODUCTION AND VALUE OF ARTIFICIAL RUBBER.

It is reported from Germany that the well-known chemical and dye firm, Farbenfabriken vormals Friedrich Bayer and Co., in Laverkusen, has considerably extended its works for the purpose of manufacturing artificial rubber. The history of the German effort to produce this substitute dates before the war. The early attempts had perforce to be given up when the price of natural rubber fell from 30 to 4 marks per kg. After the outbreak of war, when the rubber shortage in Germany became acute, it was impossible to continue the pre-war output of artificial rubber, since the necessary plant had long since been scrapped and the requisite raw materials, acetone and aluminium, were not to be had. Before long, however, both these commodities began to be produced in increasing quantities. Coal and carbide yielded acetone, and the production of aluminium was undertaken on a large scale, with the financial assistance of the State, especially by the Griessheim-Elektron concern, which in conjunction with the Metallgesellschaft set up three buildings for the purpose. After these preliminaries the manufacture of artificial rubber could be resumed. Hard rubber was comparatively easy to produce, but the production of soft rubber presented much difficulty. The news that additional

artificial rubber factories have been opened, however, makes it appear probable that there has been progress in this field. The great question is, can artificial rubber compete with natural rubber? The answer varies with the use to which the substitute is put. Quite generally, however, according to *Vorwärts*, a doubt may be expressed as to whether synthetic rubber can stand the test, especially in view of the present selling prices, which are many times greater than the prevailing prices on the London rubber market.—[*The Board of Trade Journal*, dated September 26, 1918.]

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THE second annual **sale of surplus stock from the pedigree Montgomery and Ayrshire-Montgomery herds** was held **at Pusa** on Monday, the 9th December, 1918, when 34 head fetched Rs. 5,705 under the hammer, an average of Rs. 167 per head all through.

	Average price. Rs.
Montgomery bulls	203
Montgomery bull-calves	132
Montgomery heifers	140
Montgomery cows	164
Montgomery-Ayrshire bull-calves ..	234

The bidding was very keen and there was specially a keen demand for cross-bred bull-calves as the figures show. The next sale will probably be held in March 1919.—[WYNNE SAYER.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

Sir Edward Maclagan, K.C.S.I., K.C.I.E., I.C.S., some time Officiating Member in charge of the Revenue and Agriculture Department of the Government of India, has been appointed Lieutenant-Governor of the Punjab, *vice* Sir Michael O'Dwyer, G.C.I.E. We offer him our sincere congratulations.

* * *

We offer our hearty congratulations to Major (Temporary Lieutenant-Colonel) F. S. H. Baldrey, F.R.C.V.S., formerly of the Indian Civil Veterinary Department, who has been admitted a Companion of the Most Distinguished Order of St. Michael and St. George for services rendered in connection with the war.

* * *

Major (Honorary Lieutenant-Colonel) John Walter Leather, V.D., has been permitted, on resignation of his commission in the United Provinces Horse, to retain his honorary rank.

* * *

His Majesty the King-Emperor has graciously granted to Mr. Ernest Shearer, formerly of the Indian Agricultural Service, and at present of the Egyptian Ministry of Agriculture, authority to wear the decoration of the Order of the Nile (Third Class) granted to him by the Sultan of Egypt in recognition of valuable services.

* * *

His Excellency General Sir Charles Monro, in his despatch dated 20th August, 1918, on the work done in India during the first three years of the war, mentions the names of the following, among others, for particularly valuable services rendered by them :—

Lieutenant-Colonel G. H. Evans, C.I.E., A.D.C., Indian Defence Force ;

Lieutenant-Colonel H. T. Pease, C.I.E., V.D., Indian Defence Force ; and

Lieutenant-Colonel G. K. Walker, C.I.E., F.R.C.V.S., Indian Defence Force.

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CAPTAIN (TEMPORARY) G. C. SHERRARD has been mentioned by Lieutenant-General W. R. Marshall, Commanding-in-Chief, Mesopotamia Expeditionary Force, in his despatch dated 15th April, 1918, for distinguished and gallant services and devotion to duty.

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MR. A. HOWARD, C.I.E., Imperial Economic Botanist, and Mrs. G. L. C. Howard, M.A., Second Imperial Economic Botanist, were on privilege leave for six weeks from 21st October, 1918.

***

DR. HAROLD H. MANN, Principal of the Agricultural College, Poona, has been appointed to act as Director of Agriculture, Bombay Presidency, *vice* the Hon'ble Mr. G. F. Keatinge, I.C.S., (on deputation), pending further orders.

Mr. J. B. Knight, M.Sc., Professor of Agriculture, Agricultural College, Poona, acts as Principal, *vice* Dr. Harold H. Mann, pending further orders.

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THE designation of Mr. H. M. Chibber, M.A., Second Economic Botanist, Bombay, has been changed to "Plant Breeding Expert to the Government of Bombay."

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MR. P. C. PATIL, L.AG., Acting Deputy Director of Agriculture, Northern Division, Bombay, has been granted privilege leave for three months. Mr. B. M. Desai, Assistant Professor of Dairying, Agricultural College, Poona, has been appointed to act during Mr. Patil's absence.

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RAI BAHADUR K. RANGA ACHARIYAR, M.A., Lecturing and Systematic Botanist, Agricultural College, Coimbatore, and Mr. J.

Chelvaranga Razu, Acting Deputy Director of Agriculture, IV Circle, Madras, have been admitted into the Indian Agricultural Service with effect from 6th June, 1918, and 29th May, 1918, respectively.

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THE services of Mr. Daulat Ram Sethi, M.A., B.Sc., Deputy Director of Agriculture, Orissa Circle, have been placed at the disposal of the Durbar of the Kapurthala State in the Punjab for three years.

Mr. S. K. Basu, M.A., Assistant Professor of Mycology, Sabour College, has been appointed to act as Deputy Director of Agriculture, Orissa Circle, during the absence, on deputation, of Mr. Sethi, or until further orders.

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MR. W. YOUNGMAN, B.Sc., has been admitted to the Indian Agricultural Service and appointed Assistant Economic Botanist in the United Provinces.

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MR. E. A. A. JOSEPH, B.A., I.C.S., Director of Agriculture, Punjab, has been appointed to officiate as Revenue Secretary to the Government, Punjab, and Mr. S. M. Jacob, I.C.S., officiates as Director in Mr. Joseph's absence.

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MR. F. J. WARTH, M.Sc., Agricultural Chemist, Burma, who was posted to duty with the Mandalay Battalion, Burma Military Police, has reverted to the Agricultural Department.

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MR. C. P. MAYADAS, M.A., B.Sc., Assistant Director of Agriculture, Western Circle, Central Provinces, has been transferred in the same capacity to the Northern Circle.

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THE Government of India have approved of the recommendation made by the Board of Agriculture in India in December 1917 that sectional meetings of the Board should be held in years in

which there is no full meeting of the Board, and the following sectional meetings have been arranged for this year :—

Section	Place of meeting	Date
Entomological Section	Pusa	3rd February, 1918, and following days.
Mycological Section	Pusa	20th February, 1918, and following days.
Chemical Section	Pusa	24th February, 1918, and following days.
Veterinary Section	Lahore	24th March, 1918, and following days.

Reviews.

A Survey and Census of the Cattle of Assam.—By J. R. BLACKWOOD, LL.B., I.C.S., Director of Agriculture, Bengal. Calcutta: The Bengal Secretariat Book Depôt, 1916. Price Rs. 3-11 or *5s. 6d.*

At the suggestion of the Government of India that a report on the survey and census of cattle in each province should be prepared on the lines somewhat similar to the Punjab report on the subject issued in 1910, the late Eastern Bengal and Assam Government selected Mr. Blackwood for this duty in November 1911. After the redistribution of the provinces he was instructed to prepare separate reports for Bengal and Assam. A review of the report for the former province has already appeared in the *Journal* (vol. XII, pt. IV). It is the report of the latter province that forms the subject of this review.

According to the census, the number of cattle in Assam is 4,840,348, of which, approximately, one-tenth are buffaloes. The proportion is roughly 7 head of cattle to every 10 inhabitants. This is considerably higher than the proportion in Bengal. Within the province itself the ratio in various districts differs greatly. In the Surma Valley which is comparatively thickly populated and where a great part of the land is submerged deeply for several months in the year so that cattle have to be stall-fed, 1,808,287 cattle have been enumerated, roughly, 1 to every 3 human beings. In the Assam Valley, where there are many unoccupied areas and unlimited grazing, over three millions of cattle of all sorts (3,032,061) have been found, a number not far short of the whole human population of the tract.

The breeds of cattle in Assam can be conveniently divided into three classes :—

(1) Wild cattle.

(2) Hill cattle.

(3) Cattle of the plains.

The wild buffalo is found throughout the swampy Terai of Assam. Among hill cattle, those* in Manipur are generally superior to the ordinary village cattle of the plains. In the Naga Hills people do not use their cattle for ploughing or carting; they never milk the cows but use cattle solely for food. In the Jaintia Hills a very good class of animal is found. The Garos also do not drink milk, nor do they breed cattle themselves. They generally buy bull-calves from the Nepali *bastis* in the district or in the plains, fatten them and then either kill or sell them.

The poor quality of the cattle in the plains is well known, and is largely due to climatic conditions combined to a great extent with the usual ignorance and apathy peculiar to indigenous cattle breeding, coupled with neglect, starvation, inbreeding and the usual anti-castration attitude.

In many parts during the rains the cattle stand continuously in mud and water and are fed on paddy straw. This state of affairs does not suit cattle, though it is all right for buffaloes. As a matter of fact the poor quality of the Assam cattle is in marked contrast to the fine quality of the Assam buffalo. The average milk yield of an Assam cow is less than that of a Bengal cow, being under a seer per day. The best of the local bullocks are considered by the cultivators good enough for the plough, but for heavy cart work fairly big strong animals are required and they are usually imported from Bihar districts. Improvement in the milking capacity of the cow, and better draught power in the case of bullocks are therefore required. It is possible to bring this about by crossing with suitable breeds.

In 1902 an experiment was started on the Upper Shillong farm of crossing Khasi and Bhutia cows with a bull of the Taylor (Patna)

* Particularly the bullocks, which are good draught animals.

breed. The female offspring of the cross showed much better milk results. Whereas a pure Khasi cow, it is said, will give only two seers of milk per day, the cross-bred animal gives as much as seven or eight seers per day. A pure Bhutia cow is reported to give only four seers of milk per day, while the cross-bred gives six seers.

Pure bred Patna bulls are given out by the Department in the mofussil, but the chief difficulty is to get the people to feed the bulls properly after they are sent out.

The Government of Bengal have established a cattle-breeding farm at Rangpur (which is on the borders of Assam) where experiments have been undertaken to determine whether the improvement of the local breeds is to be by rigid selection of indigenous cattle or crossing with exotic breeds, such as Montgomery, and as the problems in Assam are somewhat analogous to those in Bengal, a recent Resolution of the Local Administration states that it is proposed to wait and see the issue of the experiment there before going in for any scheme of large cattle-breeding farms. In the meantime animals from the Rangpur farm will be obtained by the Department for employment as sires in the province.

The practice of growing fodder crops for cattle is practically non-existent at present in Assam. This is mainly due to the fact that, with the exception of a few thickly populated districts where all the land not taken up for rice is flooded, Assam is better off for grazing than many other provinces. In the more densely populated portions of the province, however, the provision of grazing for cattle already presents a serious problem, and the difficulty is growing year by year. Accordingly steps have been taken by the Local Administration to set apart lands for grazing and protect them from encroachment. These grazing reserves are of four main classes :—

(1) Village grazing grounds in which agriculturists' cattle graze free of charge ;

(2) grazing grounds in more remote localities, where professional graziers may keep large herds, paying the prescribed fees ;

(3) grazing grounds in the vicinity of small towns, where cattle kept for the supply of milk to the towns pay a reduced scale of fees; and

(4) village forests in which grazing may be allowed in accordance with the rules for the management of the forest.

The quality of the cattle found in any tract does not depend merely on the abundance or otherwise of grazing, but on climate and several other equally important factors, and it is clear that ultimately the ryot in Assam will have to take to growing fodder crops. Most parts of Assam are too wet for *jowar* (*A. Sorghum*), and until a suitable substitute is found or means devised of storing grass in the form of hay or ensilage, the cattle will have to depend very largely on pasture. In the opinion of the local authorities sufficient areas, therefore, must, wherever possible, be kept as grazing grounds. Up to now over 130,000 acres have been reserved for the purpose in the Assam Valley, and over 20,000 acres in the Surma Valley. This will not go far towards the support of some four million head of cattle, but in the more populated parts where such grounds are needed, it is already difficult to get suitable land.

With the growing demand for milk and other dairy products and the consequent rise in their prices, the benefits of selective breeding and proper feeding of cattle, the necessity of introducing suitable fodder crops, and of devising means for preserving grass and other fodder, should be impressed on the people. It is hoped that the Agricultural, Veterinary, and Co-operative Departments, working together, will be able to effect a marked improvement on the present state of things.

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Bulletin of the Imperial Institute, London, January-March 1918.—This issue contains a very important article of 40 pages on "The Material Resources of Burma" by Sir Harvey Adamson, K.C.S.I., lately Lieutenant-Governor of Burma. With a fertile soil, a rainfall that has never been known to fail, abundant fisheries, magnificent forests, and rich but hitherto almost unexplored mineral wealth, Burma might be expected to offer a promising field for commercial enterprise. Yet, with the exception of rice, teak, and

mineral oil, its products have not to a great extent attracted British capital. The chief reasons for this failure are dearness of labour and deficiency in means of transport. With an area three times as large as Bengal, Burma has only about a fourth of the population of that province ; consequently the wages of labour are twice as high as in India itself. The population of Burma is rapidly expanding both by natural increase and immigration. It would expand still faster, says Sir Harvey Adamson, if the second great deterrent to the influx of capital were removed, and Burma were equipped with adequate railways and roads. To serve an area nearly twice the size of the United Kingdom, Burma has only 1,598 miles of railway. The length of metalled roads in the whole province is put down on paper as 2,100 miles ; but most of these roads are not worthy of the name. Outside towns and their environs there are few roads that are fit for other than bullock-cart traffic, and very few miles where motor traffic is possible. The provincial contract given to Burma in 1907 was quite inadequate for the equipment of the province with necessary public works, and though the contract has since been augmented by the sum of 15 lakhs of rupees (£100,000) a year, Sir Harvey Adamson considers it still insufficient to meet the requirements of the province within a reasonable time. He gives particulars of the crops, agricultural stock, fisheries, forest products and minerals, all leading to the conclusion that Burma is a land of rich resources and great potentialities. There can be no doubt that capital judiciously expended, whether by Government in improving communications and developing natural resources, or by private enterprise in exploitation, would be profitably employed. A handsome return has been obtained from the capital already expended on revenue-producing public works. Sir Harvey Adamson asserts that there is no truth in the opinion often expressed that Government is adverse to private enterprise. In the interest of the tax-payer Government is bound to reserve for itself a fair share of the profits earned from the exploitation of the products of the country. Within this limit it welcomes and is ready to give priority to private enterprise. Unfortunately applicants for concessions have too often been adventurers who desire to take much and give

nothing in return, and who possess neither expert knowledge nor sufficient capital to utilize the products which they wish to exploit. Such applications, Sir Harvey Adamson points out, must be rejected; but where *bona fide* applications for concessions are made by experts or capitalists, the Government of Burma is always ready to welcome them, and never turns them down without reasonable cause.

Among other articles in the Bulletin is one on natural dye-stuffs. The scarcity of synthetic dyes since the interruption of commercial relations with Germany has led to a search for new natural dye-stuffs and for new sources of supply of the better-known materials. Many samples of such products have been received at the Imperial Institute, and the results of their examination are given in the Bulletin. The chief developments during the war have been, however, in the increased production of natural indigo in India and Java. and fustic in the West Indies. These two dyes are much in demand for the blue and khaki cloths required for naval and military uniforms. With regard to the future of natural indigo, it is pointed out in the Bulletin that the present demand will no doubt continue during the war; but the manufacture of synthetic indigo has been started in the United Kingdom, the United States, France, Switzerland and other countries, and after the war the natural product may have to contend with even severer competition than in the past.

Correspondence.

IMPROVEMENTS IN THE QUALITY OF UNITED STATES COTTON.

To the Editor,

The Agricultural Journal of India.

Sir,

I have just received the April issue (vol. XIII, pt. II) of the Journal. I was recently talking with Mr. Erwin W. Thompson, of the United States Commercial Department, best known for his most excellent reports on vegetable oils and oilseeds. He gave me to understand that, speaking generally, improvements in the quality of United States cotton had hitherto practically always centred round some particular large estate, the owner of which was able to grow a large quantity of his particular selection and was also in such a financial position as to be able to sell his produce on a wider market than the local one usually provided. Among the smaller growers who sell locally, similar results had not generally been obtained and there had been a slight deterioration in such crops. A perusal of Mr. Roberts' article in the Journal referred to seems to corroborate this opinion, but Mr. Roberts does not so far appear to state it categorically as a result of his tour of inspection. It would be of interest if he could or could not corroborate this opinion, for one point of great importance to India is a knowledge of any methods adopted elsewhere, whereby improvements in the quality

of cotton have been effected and *maintained* among a large number of small holders and growers.

Yours faithfully,

LONDON : D. T. CHADWICK,

5th July, 1918. *Indian Trade Commissioner.*

(*Enclosure.*)

DEAR MR. CHADWICK,

* * * * * *

Mr. Roberts says (page 278) : "The chief reason for Mr. Coker's success is that he is a buyer of fine cotton and is able to give proper value for good staple." I happen to know Mr. Coker and his work, and I think the "chief reason" is quite exactly stated. The certainty that a cotton grower will get pay for his cotton in proportion to its excellence is undoubtedly of more importance in the ultimate improvement of American cotton than any other one factor, not excepting scientific breeding. I say "not excepting" because as a matter of fact in the above circumstances scientific breeding would not permit itself to be excluded ; it would naturally follow. Conversely, scientific breeding cannot succeed commercially unless the grower can see some financial advantage ; he takes no interest in the means, he wants to see the end.

The American producer usually sells his cotton in small villages to cotton buyers who are paid salaries or commissions by dealers in large cities. Often there is a community of interests among these small buyers or at least a tacit understanding for buying the planters' cotton at the lowest possible prices. If one small grower brings to market a few bales of a most superior cotton he cannot obtain more for it than his neighbour who has an inferior grade, for the village price is usually based on an average for the district. As a natural consequence the small grower cannot afford to give the time and attention to quality, he works for quantity.

A large cotton plantation, say 50,000 to 60,000 acres, could afford to employ competent men to work for both quality and quantity. Proper machinery could be provided for cleaning and

selecting good sound planting seed. Prevention of outside hybridization would be more easy because of the large area under control. The cotton seed produced could be worked in an oil mill belonging to the plantation. And, finally, the amount of cotton produced would be large enough to justify selling on its merits in the large markets where there is world competition. The greater prices thus obtained would give a commercial impetus to cotton betterment, not on the plantation itself, but by force of example, in the country at large.

* * * * * *

Yours sincerely,

LONDON. ERWIN W. THOMPSON,

American Commercial Attaché,

Copenhagen.

MR. ROBERTS' REPLY.

TO THE EDITOR,

The Agricultural Journal of India.

SIR,

With reference to Mr. Chadwick's letter of 5th July, a copy of which you have kindly sent me, I beg to note that I can confirm Mr. Thompson's opinion quoted by the Indian Trade Commissioner. The most marked example of wide improvement I came across, was in the County of Hartsville, S. Carolina. The improvement there was brought about by the work of the Pedigree Seed Company run by Mr. Coker, who is an influential man there. He has been supplying improved strains now for over 12 years and has changed the character of the cotton of the whole county, of which 95 per cent. now produces cotton of $1\frac{1}{4}''$ to $1\frac{3}{8}''$ staple as compared to barely $1''$ previously. Mr. Coker has been able to do this as he has been a buyer also, with an interest in production of a superior staple. In the ordinary local markets a superior staple rarely gets a premium and hence progress has been spasmodic.

The two essential conditions for success with small holders are—

(1) supply of seed from one source, which is continually improving; and

(2) organization of marketing to secure full value for the improved cottons from the start or as early as possible after its introduction.

The Punjab policy is based on this. In Egypt, they are now supplying seed on a wholesale scale as in the Punjab and markets are fairly well organized, but seed given out is best seed from estates and factories and not of any pedigree or definite stock.

With cotton where seed has to be purchased from outside in any case, there is no difficulty in maintaining the standard. The cost of seed per acre being so small, helps to make this easier.

Yours faithfully,

LYALLPUR: W. ROBERTS,

5th October, 1918. *Professor of Agriculture.*

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

1. Treatise on Applied Analytical Chemistry, by Prof. V. Villavecchia and others.' Translated by T. H. Hope. In two volumes. (London: J. & A. Churchill.) Price 21*s*. and 25*s*. net.

2. The Practice of Soft Cheese-Making: A Guide to the Manufacture of Soft Cheese and the Preparation of Cream for Market. Fourth Revision, by C. W. Walker-Tisdale and T. R. Robinson. Pp. 106. (London: J. North.) Price 3*s*. net.

3. A Short Handbook of Oil Analysis, by Dr. A. H. Gill. Revised, Eighth Edition. Pp. 209. (Philadelphia and London: J. P. Lippincott Co.) Price 10*s*. 6*d*. net.

4. Plant Genetics, by J. M. and M. C. Coulter. Pp. ix + 214. (Chicago, Ill.: University of Chicago Press; London: Cambridge University Press.) Price 1-50 dollars net.

5. Western Live-Stock Management, edited by Ermine L. Potter and others. Pp. xiv + 462. (London: Macmillan & Co.) Price 10*s*. net.

6. Lecithin and Allied Substances: The Lipins, by Dr. H. McLean. ("Monographs on Bio-Chemistry.") Pp. vii + 206. (London: Longmans, Green & Co.) Price 7*s*. 6*d*. net.

7. Common British Beetles and Spiders and How to Identify Them, by S. N. Sedgwick. Pp. 62. (London: C. H. Kelly.)

8. The Main Currents of Zoology, by Prof. W. A. Locy. Pp. vii + 216. (New York: H. Holt & Co.)

9. Production and Treatment of Vegetable Oils, by T. W. Chalmers. (London : Messrs. Constable & Co.) Price 21*s*. net.

10. Practical Surveying and Field Work, by V. G. Salmon. Pp. xiii + 204. (London : C. Griffin & Co., Ltd.) Price 7*s*. 6*d*. net.

11. Food Gardening for Beginners and Experts, by H. V. Davis, Second Edition. Pp. viii + 133. (London : G. Bell & Sons, Ltd.) Price 1*s*. net.

12. Rats and Mice as Enemies of Mankind, by M. A. C. Hinton. Pp. x + 63. (London : Trustees of the British Museum.) Price 1*s*.

13. Sir William Ramsay, K.C.B., F.R.S., Memorials of his Life and Work, by Sir W. A. Tilden. Pp. xvi + 311. (London : Macmillan & Co., Ltd.) Price 10*s*. net.

14. Medicinal Herbs and Poisonous Plants, by Prof. David Ellis. (London : Messrs. Blackie & Son.)

15. Canning and Bottling Fruit and Vegetables, by Mrs. Goodrich, with a Preface by Prof. F. W. Keeble. (London : Messrs. Longmans Green & Co.)

16. A Biochemic Basis for the Study of Problems of Taxonomy, Heredity, Evolution, &c., with especial reference to the Starches and Tissues of Parent-stocks and Hybrid-stocks, and to the Starches and the Hemoglobins of Varieties, Species, and Genera, by E. T. Reichert. (Carnegie Institution of Washington.)

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoir.

1. *Phytophthora Meadii* n. sp. on *Hevea brasiliensis*, by W. McRae, M.A., B.Sc., F.L.S. (Botanical Series, Vol. IX, No. 5.) Price R. 1-4 or 2*s*.

Bulletins.

1. The Improvement of the Indigenous Methods of Gur and Sugar Making in the United Provinces, by W. Hulme and R. P. Sanghi. (Bulletin No. 82.) Price As. 8 or 9*d*.

2. The Best Means of rapidly increasing the Outturns of Food Crops by Methods within the Power of the Agricultural Department. Being Notes submitted to the Meeting of the Board of Agriculture in India, Poona, 1917. Edited, with an Introduction, by J. Mackenna, C.I.E., I.C.S. (Bulletin No. 84.) Price As. 4 or 5*d*.

3. Moumachipalan, by C. C. Ghosh, B.A. (Bengali version of Bulletin No. 46 on "Bee-keeping.") Price As. 14 or 1*s*. 4*d*., net.

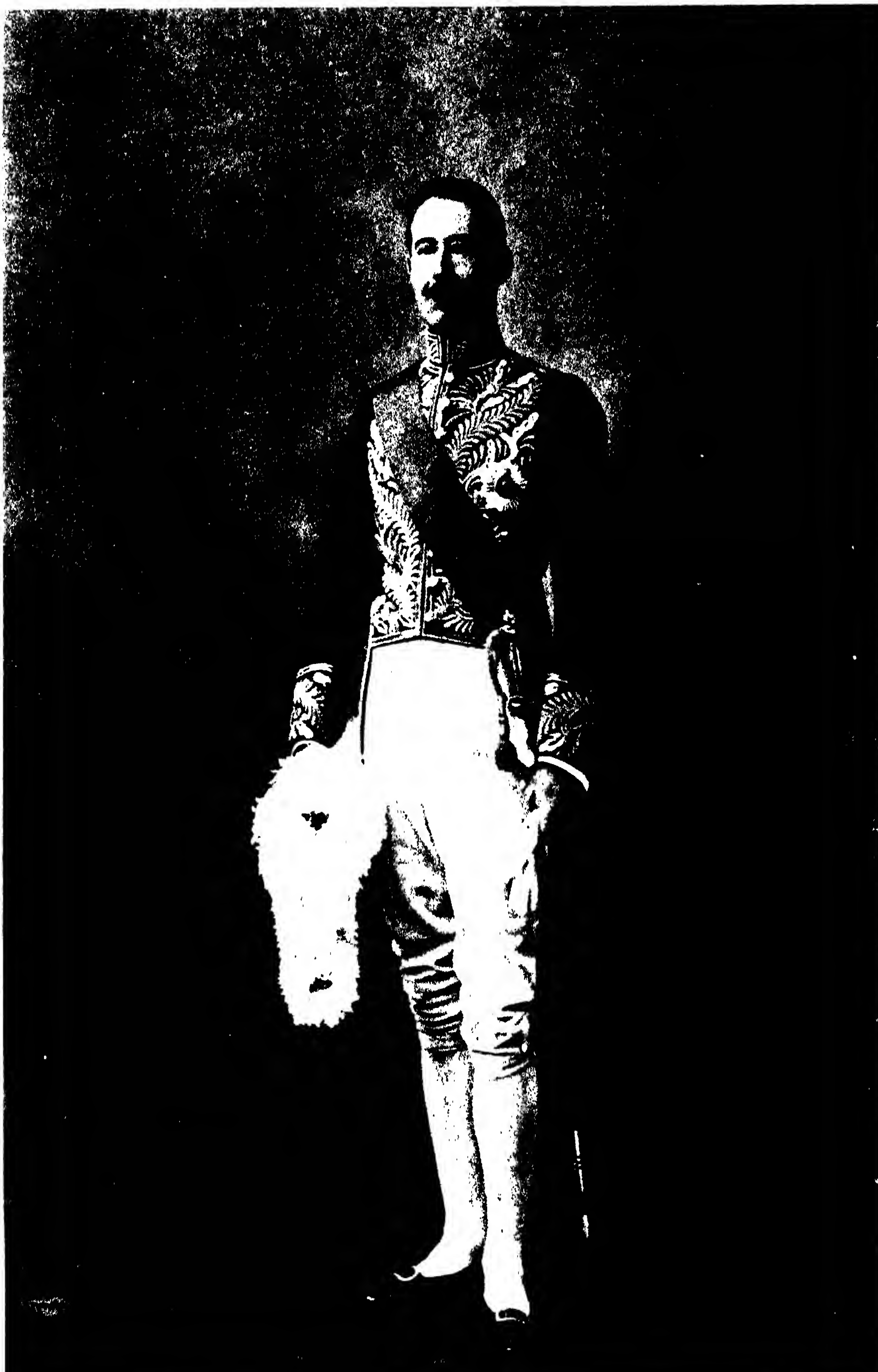
Indigo Publication.

1. The Future Prospects of the Natural Indigo Industry. The Effect of Superphosphate Manuring on the Yield and Quality of the Indigo Plant, by W. A. Davis, B.Sc., A.C.G.I. (Indigo Publication No. 4.) Price As. 4 or 5*d*.

Reports.

1. Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist), 1917-18. Price R. 1-4 or 2*s*.

2. Annual Report of the Imperial Bacteriological Laboratory, Muktesar, for the year ending the 31st March, 1918. Price As. 4 or 5*d*.



HIS EXCELLENCY THE RIGHT HON'BLE THE EARL OF RONALDSHAY, G. C. I. E.
Governor of Bengal.

Photo by Johnston & Hoffmann.

Original Articles.

NITROGENOUS FERTILIZERS: THEIR USE IN INDIA.

BY

C. M. HUTCHINSON, B.A.,

Imperial Agricultural Bacteriologist.

THE following paper was read by the Agricultural Adviser to the Government of India, in the absence of the writer, at the recent meeting of the Indian Science Congress at Bombay. It elicited a considerable discussion and we shall be glad if readers of the Journal will favour us with their views on the important points of principle it raises.—[EDITOR.]

MY intention in writing this paper is in no wise to provide a statistical review of the nitrogen requirements of India as an agricultural country with tables of figures showing the number of tons of nitrogen exported in the form of hides, oil-seeds, bones or saltpetre, and imported as manures, but rather to present one or two aspects of the general problem connected with the use of nitrogenous fertilizers in India as they appear to one who has had some considerable experience of the point of view of the agricultural chemist and of the soil biologist. The principal questions that seem to suggest themselves are—

(1) Does India require nitrogenous fertilizers, and

(2) Can the country afford to pay for them ?

Now the answer to the first question is by no means the simple and emphatic affirmative that would be given in the case of such a

country as England, and would also generally be given for India or any other country by experts unfamiliar with all the facts of the case as we know them, or should know them here. In the short time at my disposal for writing this paper it has not been possible for me to make any review of soil conditions outside those familiar to me in North-East India, and for this reason, as I said before, I am merely putting forward a view based on my own experience in order that you may consider how it accords with your own, and point out in discussion, perhaps, how singularly wide of the mark it is when applied to cases within your knowledge.

What I suggest, then, is this, that in the case of a large proportion of soils under arable cultivation in India, nitrogen supply is not to be regarded as the limiting factor so much as that of either phosphates, potash or lime, and that the use of nitrogenous fertilizers by themselves may readily lead to a lowering of fertility by exhaustion of the available quantities of these other mineral constituents of plant food. This argument of course is absolutely elementary and axiomatic, but I make no apology for introducing it as there is a large amount of evidence of its neglect on the one hand and of ignorance of its importance on the other. We find for instance planters of experience (I mean Europeans) firmly holding the belief as a body that in dealing with perennial crops—" once manure, always manure." Analyse this belief and you will discover that the planter's experience is that if you encourage the growth of a plant by nitrogenous manuring, the yield in successive years will fall below the normal unless stimulated anew by fresh applications of manure, which he cannot as a rule afford to give. In most cases further analysis will show that the planter holds the view that this result is a natural consequence of his soil having acquired a sort of vicious drug habit for nitrogen, requiring repeated and increasing doses to produce any observable effect. This attitude is by no means so improbable or uncommon as it appears and is also not at all unknown amongst quite well educated farmers in England, but the latter in most cases know how to remedy the defect by complete manuring, and many do so in full knowledge of the fact that the apparent falling off in the normal condition of the

plant is due to the unwonted drain upon the mineral resources of the soil as a consequence of the greater growth induced by the nitrogenous stimulant. The Indian cultivator on the other hand is very generally averse from the use of nitrogenous manures except in the case of rice and sugarcane, and such manures as he employs are generally either cakes or green manures, the former of which supply phosphates and potash as well as nitrogen, whilst the latter, although their stimulating effect is mainly due to their nitrogen content, supply such small quantities that this stimulation is of a low order and not comparable in soil exhausting power with that of other manures of high nitrogen content. As is well known, the ryot generally uses cowdung as fuel rather than as manure so that this source of nitrogen is lost to the soil and this practice actually constitutes a highly serious factor in the nitrogen deficiency of Indian soils generally. In Bihar the ryot has at hand a nitrogenous manure in the form of saltpetre, but although this is easily obtainable, especially in the crude unrefined condition as the " shora " of the *nuniah*, it is not used as manure even for valuable crops. This seems remarkable, especially as the *nuniah* who makes it is almost invariably a cultivator as well, or at least one or more of his family are ; the reason invariably given, however, is that the use of saltpetre results in the loss of *tāqat* by the soil, and that the only remedy for this condition is fallowing, implying the loss of a crop.

Here then we have the attitude of the ryot towards nitrogenous manuring based on his practical and inherited experience. His scheme of farming depends upon getting a continuous series of crops, representing low yields from the soil, but by reason of this lowness avoiding loss of *tāqat* or reduction in fertility. For the same reason the Indian cultivator, in such a tract as Bihar where cultivation has reached a high pitch of perfection, is chary of using high yielding varieties of crops or of carrying cultivation, in the sense of ploughing and harrowing, to a high degree because he knows that the large crop or series of crops will inevitably be followed by correspondingly small ones.

Finding such a belief firmly rooted in the minds of the cultivators in such a tract as North Bihar where the fertility of the soil is so

great as to allow it to carry one of the densest rural populations in India, one is naturally led to inquire into the causes underlying it. Various limiting factors in crop production are found at once, of which the most prominent is water supply; the Bihar cultivator is a past master both in the art of conservation of soil moisture and of securing its proper vertical distribution at sowing time, and, in common with all other Indian agriculturists in non-irrigated areas, looks upon the distribution of rainfall as the primary factor in determining crop production. It is interesting to find that in Bihar the pessimistic general outlook of our British farmer so far as weather is concerned finds its counterpart in the belief that a good year is generally followed by a bad one, not necessarily because of the improbability of two successive years of good weather, but once more because of the exhausting effect of a bumper crop upon the soil. Here again the ryot hopes for nothing better than a medium crop on an average of years and shows his conviction, based on generations of experience, that there is some, to him quite natural, adverse influence which rules and limits production. We, with our advanced knowledge of agricultural chemistry and biology, can say with some probability of correctness to what this adverse influence is mainly due, but can we do anything to neutralize or remove it? *Felix qui potuit rerum cognoscere causas*; but is it not possible that we may discern a cause without fully understanding its effect? Let us take the case of nitrogen as one of the most prominent factors in soil fertility.

Here we have an element existing in the soil sometimes in large quantities, only a small fraction of which is available at any one moment as plant food. Availability depends upon nitrification and this again depends upon a complete series of chemical changes due to bacterial action, starting with the proteid nitrogen of the plant cell, as found in the organic refuse of the soil, and going through such stages as peptones, polypeptids, amino-acids and ammonia to the final condition of nitrites and nitrates. Now there appear to be points in the early parts of this series at which the style of decomposition may diverge from its natural orderly progression into side-tracks leading to the formation of compounds which do not

readily lend themselves to further progress to the goal of nitrification; consequently we have a natural tendency in the soil towards the accumulation of residual masses of nitrogenous organic matter, and were it not for this tendency there appears to be no reason why the greater part of the nitrogen in the soil should not be nitrified simultaneously instead of only a small fraction. It is a well-known fact that in peat soils the relative proportions of carbon and nitrogen vary as the peat becomes older, the carbon becoming relatively less and the nitrogen relatively more. This is also the case to a less degree in all uncultivated soils. This condition in peat soils is no doubt due to the influence of the semi-anaerobic conditions characteristic of such soils during their formation upon the kind of bacterial action responsible for decomposition of the nitrogenous organic matter they contain, and in all soils the relative amounts of nitrate-nitrogen and of reserve nitrogen will vary in accordance with the aeration or otherwise of the soil itself. When we increase the apparent fertility of the soil by draining and intensive cultivation we are simply using up reserve nitrogen at a rapid instead of at a slow rate, and unless steps are taken to replace it at the same rate, sooner or later depreciation in the fertility of the soil will inevitably occur. But in very many cases exhaustion of some other constituent such as P_2O_5 occurs first and even careful green-manuring, which may postpone nitrogen exhaustion for some time, is unable to avoid this result. Another frequent failure is that of the non-nitrogenous organic matter of the soil which is rapidly destroyed by intensive cultivation, and the loss of which is only with difficulty made good by green-manuring or caking; one great evil of such loss, apart from the obvious one of destruction of tilth, is the interference with the natural fixation of nitrogen by nonsymbiotic soil organisms. This highly important source of soil nitrogen requires careful investigation, especially in India where climatic conditions and the high temperature of the soil enormously enhance the activity of soil bacteria and with it the importance of such methods of adding to fertility as depend upon their action. At Rothamsted fixation of nitrogen by nonsymbiotic soil organisms has been shown to add nearly 100 lb. per acre per annum to an uncultivated soil; at Pusa

this amount has been greatly exceeded, but in this case artificial additions of carbohydrate were made so that we have only an indication of the potential activity of azotobacter under optimum conditions. The point to be emphasized however is this: neither at Rothamsted nor at Pusa has such a high rate of nitrogen fixation been observed in soils under arable cultivation, even making allowance for the nitrate formed and removed either by the crop or by drainage. Fixation no doubt goes on in cultivated soil but its rate is probably lowered by the want of sufficient carbohydrate to allow of its proceeding at a maximum pace. In a fallow or uncultivated soil such carbohydrate accumulates along with the organic matter formed by wild vegetation or algal growth, but cultivation lowers the supply, and the better the cultivation and the more complete the drainage and aeration so much lower will be the quantity of food available for nitrogen-fixing organisms in the soil. Here we have another instance of the necessity of due consideration in introducing a Western method into the East. In England complete drainage and cultivation are the foundations of successful farming; in India although the same operations will generally result in an increase of crop and of apparent fertility, yet the ultimate result may easily be depreciation in the condition of the soil due to over-rapid formation of nitrates and their loss in drainage water and to the rapid decrease in the content of organic matter in the soil accompanied by loss of tilth and of nitrogen-fixing power.

Apart from the deleterious effect of over-cultivation upon fixation of atmospheric nitrogen, the lowering of the content of organic matter in the soil by this means has another less direct effect in reducing the numbers of soil bacteria and thereby lessening the valuable influence they exert upon the retention of soil nitrogen. Where organic matter is plentiful these bacteria will be sufficiently numerous to reconvert any excess of nitrate formed into proteid nitrogen and thus prevent its leaching out of the soil by rain as happens in over-cultivated and over-drained soils. Thus in order to avoid loss of tilth and of organic matter, reduced fixation of nitrogen and formation of nitrate, a proper mean must be struck between excessive cultivation which will give large crop yields

but reduce fertility, and no cultivation at all; this is in cases where manure is unavailable or is too costly, but my object in uttering this warning is to point out the absolute necessity of realizing the facts of the case connected with the utilization of intensive cultivation and especially of improved high yielding varieties, and of co-ordinating the activities of the Agricultural Department so that the plant breeders shall not be in a position to say: "We have given you improved machinery for making use of solar radiation, where is the raw material necessary to keep it in operation?" I repeat therefore that in such a tract as Bihar experience shows that the introduction of intensive methods (sometimes referred to as improved methods) of cultivation and of heavy yielding varieties of crops, is necessarily followed by reduction in the reserve food supplies of the soil and sooner or later by reduced fertility. This loss of fertility is by no means confined to Bihar; similar conditions may be found from the Punjab to Assam. It follows therefore that unless India is to be content to produce crops at a rate determined for each soil by the nitrogen-fixation rate in that soil and thus to give up the advantages of improved varieties of crops, nitrogenous manures are necessary in this country just as they are elsewhere. Research and experiment will no doubt show us how to make the most of our existing nitrogen supply and even how to increase its amount by improving the conditions for fixation, either symbiotically or asymbiotically, but my opinion is that our improved machinery for converting soil nitrogen into crops is even now considerably in advance of the supply of raw material and is likely to become more so in the future. As I have pointed out before, nitrogen is by no means the only limiting factor and any attempt to provide this element alone will merely result in more rapid depreciation of a large majority of our soils. Although intensive cultivation will rapidly bring into an available condition large amounts of the reserve nitrogen of the soil, it appears more difficult to produce the same result at anything like the same pace so far as its mineral constituents are concerned. Solubilization of such substances as natural phosphates, whether existing as constituents of the original mineral particles of the soil or in organic combination

as plant residues, is a process depending largely upon bacterial action the slowness of which is frequently indicated by the difference between the "available" and total phosphates in the soil chemist's analysis. Some experts, mostly in America, have asserted that the soil solution always contains sufficient minerals, such as phosphates, to satisfy the food requirements of the crop, but this theory cannot be considered tenable in the light of general experience with manures, and especially of work at Rothamsted on this particular point. We come back therefore to the fact that if nitrogen is made available more rapidly, relatively as plant food, than minerals such as phosphates, the available supply of the latter will be exhausted and infertility result.

We have then two natural sources of available plant food in soil, both depending upon slow biological processes going on in the latter and setting a natural pace for crop production; any artificial interference with the parity of these processes must result in a lowering of fertility only to be avoided by judicious manuring or recovered from by fallowing, or manuring, or both. It must be noted also that application of phosphates without regard to the sufficiency of the nitrogen supply may do great harm by bringing crop growth above the safety point which should properly be fixed by the natural limiting factor.

Let us now turn to the second question: Can India pay for the nitrogenous or other manures which I have endeavoured to show are necessary? This of course is entirely a question of the relative values of increase of crop and cost of manure, and it is one which requires not only consideration of local values as they exist under present conditions but of the possibility of lowering the cost of manures, probably by measures securing cheaper transport, and of popularizing the use of such fertilizers as cakes and fish manures (and especially the latter), and, by creating a steady demand for indigenous products, helping to stem the flow of such commodities as oilseeds from this country. It is not within my province to suggest how the present unsatisfactory state of affairs with regard to export of oilseeds can be altered, but, as is well known, the protective tariff in France and Italy against foreign oils at present makes it

economically unsound to crush seeds in India ; nevertheless the fact remains that this country is exporting valuable nitrogen and getting only a byproduct price for it, whereas the oilcake, if retained in India, would be invaluable to agriculture, being, as has been shown in numerous localities and for a great variety of soils and crops, the soundest nitrogenous manure obtainable. It seems certain that co-operative credit will enable the cultivator to use manures more freely in the near future ; it is our duty therefore to provide reliable information as to how to use them and to make such arrangements as are possible to supply them at the lowest possible cost.

I have taken up so much of your time in considering the necessity of manuring that I cannot make any pretence of dealing adequately with the subject of providing manures whether nitrogenous or otherwise. The whole question requires and demands immediate and exhaustive inquiry at the hands of the Agricultural Department. Can we use hydro-electric power economically in India for the production of combined nitrogen, and can this compete with imported products such as Chilean nitrates, nitrolim and calcium cyanamide ? Can we divert the stream of organic nitrogen which flows out of India in the form of oilseeds, bones and hides so as to use the by-products as a source of this element ? Can we extend the production of saltpetre so as to make better use of this valuable method of recovering nitrogen which otherwise is lost to agriculture ? Can we recover as fish manure any considerable portion of the nitrogen which goes by rivers, streams and sewers into lakes and into the sea. and can we by any means increase our soil stock of nitrogen by the popularization of sounder methods of crop rotation with legumes and of green-manuring ?

So far as phosphates are concerned there can be no doubt that India would benefit enormously by the greater use of such natural supplies as can be obtained from Christmas Island and perhaps Egypt or even in Bihar. But here again commerce and agriculture must be brought together to their mutual benefit by the wise guidance of the Agricultural Department so that the uninstructed cultivator may not suffer disappointment as a result of undue commercial enterprise, and on the other hand the merchant's

chance may not be prejudiced by want of proper information. In this connection it is worthy of remark that by reason of the high average temperature of the soil and the proportionate intensity of bacterial action therein, this country is probably in a position to utilize large quantities of raw phosphates in conjunction with green-manuring without the expensive intervention of sulphuric acid. This point again requires and demands the earnest attention of the Agricultural Department.

The most important point in this enquiry is one to which I would now draw your attention with a view to obtaining your several and collective opinions thereon. It appears to me that the following principles are involved in the question of whether India as an agricultural country can afford to buy manures :—

(1) A country which is farming on old soils cannot compete with one utilizing virgin soils so long as the latter is recklessly willing to pay dividend out of the capital reserves of plant food in those soils.

(2) A country possessing limited mineral wealth and only insignificant industrial resources cannot compete agriculturally on even terms with a country which owing to its possession of such resources can afford to pay for the manures necessary for intensive cultivation.

These remarks need qualification in respect of special crops such as rice, jute, cotton, and tea for which correspondingly special conditions of climate and soil are required, but the case of these crops emphasizes the necessity of considering the possibilities of competition between India and such countries as America and Canada so far as wheat growing is concerned. Again then we come to the question whether India can afford to adopt the policy of raising crop production above the level fixed by Nature and adopted by the Indian cultivator. In my humble opinion this can be done to a certain extent by making the best use of the natural resources of the country, but it is to be considered whether India can at present afford to use high yielding varieties of crops and intensive cultivation since she cannot at present afford to pay the

world's market price for imported manures such as would be required to prevent depreciation of her soils under such conditions.

The improvement of agriculture in India from the point of view of utilization of manure is entirely a question of economics requiring a very wide view and extensive knowledge for successful solution. Can the country as a whole go on exporting nitrogen, phosphates, and potash indefinitely without sooner or later becoming bankrupt agriculturally ? Can indeed the rural districts supply food to the urban centres with their rapidly growing populations ? The old condition of affairs in which, owing to lack of facilities for communication and transport, a district was self-supporting, is being replaced by one in which increase in such facilities is leading to heavy exports of foodstuffs from the fertile areas and even to the replacement of food crops by revenue-producing crops such as jute and cotton. Measures must therefore be taken to ensure that the transport facilities which are giving rise to this condition of impoverishment of our soils shall be fully utilized to convey manures from such centres as can provide them to the districts where they can be profitably employed as the raw material for crop production ; no method of Government control can prevent the cultivator from substituting revenue crops for food crops, but Government can perhaps so influence the general situation by helping to lower the cost of manures and so allowing of the full utilization of the crop-producing powers of our agricultural machine—the improved plant—as to make revenue crops include rather than exclude the food-producing classes.

The original questions, then, may be answered as follows :—

(1) India does require nitrogenous fertilizers but she also requires a supply, *pari passu*, of other soil constituents without which in many, nay in most, cases nitrogen will do more harm than good.

(2) India cannot afford to pay for imported nitrogenous fertilizers at the same rate as other countries whose mineral wealth and local consumption gives them an economic advantage, but on the other hand there are possibilities in this country of making better use

than at present of indigenous supplies of nitrogen. At the same time it would be fatal to divorce consideration of nitrogen supplies from that of other manurial constituents, so that the question resolves itself into whether India can afford to adopt the policy of raising *and keeping up* the general fertility of her soil, that is to say of taking up intensive farming, rather than continuing the indigenous method of keeping the crop yield down to the level to which it is naturally restricted by the continued normal rates of nitrogen fixation and mineral disintegration. One thing is certain and that is that it must be wrong to devote most of our energies and attention to the provision of high yielding varieties of crops and to intensive methods of cultivation without first making adequate provision against the depletion of the soil which will certainly follow their unrestricted use.

NITROGEN FIXATION IN INDIAN SOILS.

BY

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At the recent meeting of Agricultural Chemists held at Pusa, a resolution was passed drawing attention to the importance of investigations concerning the biology of Indian soils and the necessity of creating posts of soil bacteriology in all the Provincial Agricultural Laboratories to carry them out. This expression of opinion by the meeting was based upon recognition of the very numerous problems connecting soil fertility and soil biology, but of all these the conditions determining the fixation of atmospheric nitrogen in the soil must, I think, be considered of paramount importance. This subject has had but little attention from soil biologists up to now, mainly because although undoubted additions of nitrogen take place in the soils of countries with temperate climates, as has been shown at Rothamsted and elsewhere, yet the amount thus added is relatively small in cultivated soils, partly because of the comparatively low organic matter content of such soils as a consequence of intensive cultivation and partly, and probably mainly, because the low temperature of such soils limits the rate of the beneficial action responsible for fixation and so keeps down the amount thus added to comparatively insignificant proportions. Now in India we have, as I have pointed out elsewhere, relatively high temperatures in soil and correspondingly high rates of bacterial action, so that any results from such activity will be correspondingly great. This has been shown to be so in the case of ammonification and of nitrification, and we have indeed in connection with nitrogen fixation itself an undoubted proof of

the relative rapidity with which this occurs in Indian soils in the short growing period of legumes in our tropical and sub-tropical districts. This rapid growth, a direct consequence of the high temperature of soil and air, is accompanied by a correspondingly rapid fixation of nitrogen by the root nodule organisms living in symbiosis with these plants; thus in a growing period of six weeks a crop of *Crotalaria juncea* will fix as much nitrogen as a crop of clover in England in as many months, and similarly in eight weeks' time nitrification of a full dose of oilcake will be completed in Pusa soil, whereas in England this might take anything from four to eight months. In the case of symbiotic nitrogen fixation, moreover, we are limited to the growing period of our leguminous crop, a very short one when we consider that part of the time only during which active bacterial action is going on in the nodules; in non-symbiotic fixation such as that effected by azotobacter and various clostridial forms so far as we know at present there is no such limited period, nor is intensive cultivation generally practised in India with the consequent rapid reduction in the organic content of the soil which apparently in England is responsible for limiting this kind of bacterial action. In a very large number of Indian soils, however, we find a natural low content of organic matter, and also a very general prevalence of drought over considerable periods of the year, resulting in a reduction of the moisture content of the soil below that favourable to bacterial activity; these unfavourable conditions might therefore be considered to reduce the importance of asymbiotic nitrogen fixation as a serious source of soil nitrogen in this country, and to relegate this question to the same relatively insignificant position in India as it has occupied in the past in countries with temperate climates. Observations made at Pusa of the rate of fixations of nitrogen both in field soils and in the laboratory have confirmed my opinion that not only is the amount of nitrogen taken from the air and added to the soil by azotobacter of considerable economic importance, but that this amount may vary within such wide limits that it seems highly probable that, were we in possession of more accurate information as to the causes of such variation, we should be able to increase this amount very considerably

quite possibly by mere soil management such as is made use of to secure nitrification, or possibly by the addition of some stimulating substance which may be absent in some soils. The accepted theory at present assumes the rate and amount of nitrogen fixed to be determined or at least limited by the carbohydrate content of the medium in which the organism is acting. In Pusa soil in the field the addition of sucrose in varying quantities was followed by proportionate increase in the amounts of nitrogen fixed; this amounted in some cases to several thousand pounds per acre per annum, but the cost of the sugar was relatively high and precluded its use as an economic measure. Similar results have been obtained by the use of molasses in sugar-growing countries such as Mauritius, but here again the cost of the application was out of proportion to the value of the result. Conclusions based only on the assumption that nitrogen fixation is limited by the artificial addition of comparatively expensive carbohydrate materials would therefore appear to be unfavourable to the theory that such a source of soil nitrogen is likely to be of economic importance, but I have for some years been of opinion that the wide variations above referred to as occurring in Indian soils must have their origin in some other cause than mere differences in the carbohydrate content of the soil. In all Indian soils which I have examined, algæ are found, fulfilling their natural function of adding to the organic matter content of the soil by taking the necessary carbon from the CO_2 of the air. We have only to assume a symbiotic relationship between such green algæ and nitrogen fixers such as azotobacter, the one supplying carbon and the other nitrogen, both drawn from the air, this symbiotic action consequently enriching the soil and not depleting it, and we can then understand how nitrogen fixation can proceed, limited only by the necessary soil moisture and the presence of such inorganic salts as are requisite for the growth of these organisms. It has yet to be discovered whether the variations observed in the amounts of nitrogen fixed in various soils are due to imperfections in this symbiotic relationship, resulting perhaps from the association of inappropriate strains or species of algæ or of azotobacter, or the absence of appropriate amounts of some limiting soil constituent.

Alternatively it might be found that the total annual fixation depends upon the coincidence of appropriate weather conditions with seasonal variations in the activity of one or both of the symbiotic organisms. Control of this factor would probably then depend again upon soil management with reference to moisture and possibly aeration, and as azotobacter is found at considerable depths in some soils the former is the more probable source of variation.

One very probably important factor in fixation of nitrogen in soils, as it has been shown to be by Golding in artificial culture, is the continuous and concurrent removal of the products of the bacterial action involved in the process of fixation. As in many other natural processes accumulation of certain products appears to interfere with their continued formation ; in the case of fixation of nitrogen as the result of symbiosis between radicicola organisms and leguminous plants, the latter appear to remove from the root-nodule such products of the physiological functions of the former as might hinder continuation of this process. There is reason to believe, as the result of recent work in this laboratory shortly to be published, that the nitrogen fixed by azotobacter in the soil is after its fixation at any rate partly present in the latter in the soil water. Accumulation of this nitrogenous organic matter in the near neighbourhood of the organisms responsible for its formation may very well interfere with their further action either by limiting reproduction or metabolic activity or both. This accumulation would be prevented to some extent by movements of soil water and it is very probable that this factor in the environmental conditions so far as the activity of azotobacter is concerned, may be found of prime importance. The apparent reduction in rate of fixation in a soil under crops, may be due to competition between the latter and the nitrogen fixing organisms for such soil constituents as available phosphates, potash, or lime, which may be in defect in various soils, and any enquiry into this subject must necessarily take account of this possibility.

Recent work in the Punjab carried out by the Agricultural Chemist to the Government of the province, has conclusively demonstrated the practical importance of this question and the

pressing need for further work on the subject. Mr. Wilsdon, and Mr. Barkat Ali, his Bacteriological Assistant, have found nitrogen fixation in certain Punjab soils amounting to an addition of as much as 30 per cent. to the nitrogen content of the soil during the year, and this in soils under wheat containing only comparatively small quantities of organic matter. The enquiry is still at an early stage and the conditions determining this astonishing rate of fixation are not yet known, but it is clear that this is an outstanding case of the kind I have referred to above where some apparently insignificant cause has been responsible for what must amount to an enormously potent factor in maintaining the fertility of the soil. It is evident that could this determining factor be discovered, in all probability we should be in possession of a means of drawing, without undue expenditure of energy or of money, upon the inexhaustible supply of nitrogen in the air, and so avoiding the depletion of this soil constituent which is so likely to occur as a result of the adoption of intensive methods of cropping and cultivation now in vogue. For this reason amongst others I would call attention to the prime necessity of appointing soil biologists to carry out work on this vitally important problem in every part of India; were no other biological problems of importance to agriculture known to require elucidation, this one alone would justify the expenditure necessary to secure its adequate investigation.

Note.—The results obtained in the Punjab have not yet been published, but the following extract from a recent letter received from Mr. Wilsdon by the writer will be of interest:—

"Determinations were made of the fluctuations of total nitrogen in various Punjab soils during the fallow of a wheat after wheat rotation. In 1916 extraordinary amounts were fixed, the average for all the soils examined being as much as 58 mgm. per 100 grams of soil. The largest fixation was 104 mgm. in Lyallpur soil. The determinations were repeated again in 1917 at Lyallpur only, and no increase was detected. In 1918 arrangements were made to extend the work over all the chief districts of the province. In most soils the nitrogen remained constant or fell, but in some, fixations of 30, 20, and 16 mgm. were observed."

Here, as Mr. Wilsdon points out, the chief interest lies not only in the quantities of nitrogen fixed but in their variation in amount from year to year, thus inevitably suggesting the existence of an unknown factor which it must be our business to determine and if possible control. Dr. Harrison in Madras and Mr. Warth in Burma have found evidence of similar important additions of air nitrogen to rice soils under swamp cultivation.

THE TRUE SPHERE OF CENTRAL CO-OPERATIVE BANKS.

BY

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In July last an article entitled the "True Sphere of Central Co-operative Banks" by Mr. R. B. Ewbank was published in the *Agricultural Journal of India* (Vol. III, Pt. III). To this Mr. N. K. Kelkar, Governor of the Central Provinces and Berar Co-operative Federation, has recently (Vol. XIV, Pt. 1) made a reply, to which I propose to add a few words on behalf of the central banks of Bihar and Orissa.

I should like to start by subscribing to Mr. Ewbank's main theory that our object should be to build up healthy independent primary societies and that everything must give way to this object. I agree that in so far as the present system tends to concentrate all power and discretion in the central bank, in so far the central bank becomes "the seat of responsibility, the checker of applications" of individual members of societies, "the granter of credit," it is an evil, though it may in some circumstances be a necessary evil. On the other hand, I venture to disagree with him and even, it may be, though I am not quite sure of his meaning, with Mr. Wolff, with the former on both theory and fact and the latter on theory only.

To take the theory first. I see no reason why a central banking union should not combine propaganda, organization, and inspection with its banking business. Mr. Ewbank says, "The true function of a central bank is simply to say 'yes' or 'no' to loan

applications and when it says 'no' to explain why, in order that a society may know in what way its credit is defective . . . Their true sphere is finance and not administration and control." In the words of Mr. Wolff, "The central bank is, when all has been got shipshape, to serve, not to be tutor to, the local banks. It is in fact designed to be a 'bank.' In Europe I prefer that it should be a joint stock company. Its manager's proper business is that of bankers qualified to meet commercial bankers on their own ground and form a link between the co-operative and the banking world." Now it seems to me first of all that there is some confusion of thought in all this. Is the central bank being condemned because it combines banking with propaganda, organization, and inspection, or because it dominates the societies too much? If it is the former I am prepared to join issue merely as a pure question of theory. Suppose you have your "pure" bank which does nothing but say "yes" or "no," how does it get its knowledge to enable it to discriminate? Apparently from the reports of the union and the audit notes. If it does no inspection it must rely on these and become a mere machine to register the unions' orders, as the Mandalay Central Bank registers those of the Registrar. Then to all intents and purposes it is the union that is doing the banking, only it keeps a separate issue department, as it were. Why should not the two things be combined? It is merely a matter of organization, and the advantages of combination are obvious. A banker cannot have too intimate a knowledge of his client's business. The more he knows the safer he is, and the better it is in the long run for his client. Even the idea that it is wrong for a banker to take the initiative in starting new ventures is out of date. The Germans embarked on this business and with such success that, had they not been in such a hurry, they were about to conquer the world by it. Every other country is now copying the good points of their system. If this intimate connection between banker and client works in industrial and commercial banking, where the interests of client and banker are to this extent opposed that the banker thinks primarily of himself and his capitalist shareholders, then surely it will work doubly well in a series of linked co-operative

institutions where the interests of client and banker are identical. Therefore I say that theoretically I can see no objection to a central bank conducting propaganda, and founding and inspecting societies, but rather the reverse. In practice, we have the good reason (which Mr. Ewbank recognizes) for the combination that we have so few competent workers that we *must* combine. There is therefore no need to argue the matter.

But I do believe and always have believed that the more inspection can be decentralized the better. We have found in Bihar and Orissa by experience that one central bank cannot finance and manage more than 100 to 150 societies with success without some intermediate link. This we hope we have found in the guarantee union, but some organization there must be outside the societies themselves which can act as guide, philosopher and friend to the primary societies. Too much centralization and domination is undoubtedly bad—and it is a fault into which a federation or a guarantee union can fall just as easily as a central bank—but with our societies in Bihar and Orissa a strong hand from without is absolutely necessary at the present stage. The description which I once wrote of our societies, which Mr. Crosthwaite quoted in his excellent book[1], will show how essential this is. These societies probably form a great contrast with most of the societies Mr. Ewbank knows in Bombay, and this accounts to a great extent for his different point of view. What *we* require is a benevolent despot anxious to train his subjects to early home rule—in fact what the Government in India claims to be and its critics say it is not. In my experience, as many central banks fail from acting the part of King Log as from playing the more energetic rôle of King Stork.

So much for theory, and it is when we get to fact that I have more complaints to make. Mr. Ewbank's picture of the activities of a central bank may be true of some provinces, but it is certainly not true of Bihar and Orissa. Our central banks have nothing whatever to do with audit, except to see that defects pointed out in audit

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[1] "Co-operative Studies in the Central Provinces and Berar," by H. R. Crosthwaite, C.I.E.

notes are remedied. Up till now the auditors have been appointed and paid by Government. Our new federation will shortly take over their pay and appointment, but it is a federation of primary societies and not of central banks; while the Registrar is *ex-officio* Governor and appoints and controls all the auditors. None of the societies, so far as I can remember (though it is possible that there are one or two exceptions), are now required to deposit their reserve funds in central banks, although most of them have been persuaded to invest part of them in Government paper. In so far as they are at the mercy of central banks, they at least can, in most cases, if they wish, themselves direct the policy of the central bank. The following statement shows the number of individual members and societies in each of our central banks and unions and the amount of share capital paid up by each class :—

Serial No.	Name of central society	Date of establishment	Number of members		Share capital paid up			Remarks
			Individuals	Societies	By individuals	By societies	Total	
					Rs.	Rs.	Rs.	
1	Provincial Bank ..	16-3 14	17	27	20,000	86,000	106,000	In 14 out of 22 central banks the societies have already acquired a controlling interest.
2	Bihar C. B. .	8·11·11	..	77	5,830	4,884	10,714	
3	Barh C. B. ..	30-9-13	59	72	6,840	9,924	16,764	
4	Gaya C. B. ..	6-6-13	60	61	9,480	4,610	14,090	
5	Nawada C. B. ..	14-5-10	76	180	10,000	9,660	19,660	
6	Jehanabad C. B. .	13-10-13	57	122	8,050	9,368	17,418	
7	Aurangabad C. B .	19-11-14	88	69	2,400	2,596	4,996	
8	Muzaffarpur C. B.	24-5-13	80	67	9,950	5,220	15,170	
9	Siwan C. B. .	24-2-15	51	84	7,550	6,052	13,602	
10	Gopalganj C. B. ...	22-3-17	50	29	2,440	1,112	3,552	
11	Rohika Union .	21-12-09	13	56		11,776	11,776	
12	Daulatpur C. B.	13-6-14	22	84	32,475	6,034	38,509	
13	Bhagalpur C. B. ...	12-5-13	112	28	9,620	1,370	10,990	
14	Madhipura C. B. ...	2-9-11	95	57	16,170	11,082	27,252	
15	Supaul C. B. ..	30-5-14	64	42	7,220	2,766	9,986	
16	Banka C. B. ...	5-10-15	13	40	960	690	1,650	
17	Purnea C. B. ...	17-3-14	67	40	8,710	2,488	11,198	
18	Ranchi C. B. ...	10-6-10	63	155	3,628	3,820	7,448	
19	Banki Union ...	26-3-10	...	80	...	21,270	21,270	
20	Jajpur C. B. ...	30-10-14	53	48	6,250	1,804	8,054	
21	Khurda C. B. ...	22-3-12	45	62	3,598	8,502	12,100	
22	Balasore C. B. ...	19-2-16	14	37	1,240	2,438	3,678	
23	Kendrapara C. B. ...	29-5-18		Newly	formed.			
24	Cuttack C. B ...	9-5-18						
25	Bettiah C. B. ...	12-7-18						

Except in the case of the provincial bank, each member and each society has only one vote whatever shares may be held, and it is therefore only a few years in each area before the societies

have the real power, if they can learn to use it. Already they are beginning to make their weight felt in some areas and it will not be long before this tendency will greatly develop.

As for the assessment of credit, central banks do not assess the credit of individual members. This is fixed at the annual general meeting of the primary society under the presidency of a director of the central bank, the manager or, if it exists, a representative of the guarantee union. Without such guidance, in most of our societies such meetings would be a farce, for the simple reason that only one or perhaps two of the members can read and write, and these members, even if capable of conducting a general meeting according to rule, inevitably tend consciously or unconsciously to abuse their position of vantage. The results of these meetings, duly communicated to the central bank, enable it to fix a credit for the society as a whole and to see that no individual member transgresses the limit imposed without recourse to a special general meeting.

Mr. Wolff's objection that a central bank's proper business is to form a link with the commercial world hardly applies in India, where this link is found in the provincial bank, which provides professional banking experience and joins up the societies of the province with the money market. To Mr. Willoughby I would say that he has obviously got the wrong type of men as directors. What we find in Bihar is that the best directorate is a mixture of town dwellers and small landholders resident on their estates. Wherever the latter can be secured, our central banks do excellent work. Where they are not forthcoming, as is usually the case in central banks situated at the headquarters of districts. central banks fail--but from doing too little and not from doing too much and the Registrar may have to replace them by banking unions of the pure type, or to arrange to finance groups of guarantee unions direct from the provincial bank.

The gist of my reply to Mr. Ewbank is, therefore, that I dispute his theory that it is wrong to combine co-operative banking with propaganda, organization, and inspection, and that so far as Bihar and Orissa is concerned some of his facts are not correct. All the same he has done us all a service in bringing prominently before the public

a danger against which constant warnings have been sounded in our province. If central banks, guarantee unions, or federations centralize, more than is absolutely necessary, either finance or control, the peasants of India, always ready to rely on Government assistance, will never learn to think for themselves and to manage their own affairs. They must have advice and control, but *in their own villages* and not at headquarters, and this advice and control must take the form of making them themselves decide their own policy, whether in respect of new members, or personal credit or what not. If they do this under guidance, in time they will learn to do it themselves; otherwise co-operation will never rise above the level of a semi-official *takavi*.

SECTIONAL MEETINGS OF THE BOARD OF AGRICULTURE IN INDIA.

I. THE THIRD ENTOMOLOGICAL MEETING.

THE Third Entomological Meeting was held at Pusa from 3rd to 15th February, 1919, and was attended by upwards of fifty delegates interested in the various aspects of entomological work in India. Besides the Pusa staff of the Entomological Section, the Agricultural Departments were represented by delegates from Assam, Bengal, Bihar and Orissa, the United Provinces, the North-West Frontier Province, Bombay, the Central Provinces, and Madras, as well as from Hyderabad, Baroda, Central India, Patiala, Mysore, and Travancore. The Forest Department and the Indian Tea Association also sent representatives in the persons of Mr. C. Beeson, Forest Zoologist, and Mr. E. A. Andrews, Entomologist to the Indian Tea Association, whilst Captain Froilano de Mello attended as a delegate from Portuguese India. This was also the first of these Sectional Meetings to attract visitors from outside of India, the Egyptian Government sending an official delegate in Dr. Lewis H. Gough, Director of the Entomological Service in Egypt, and Mr. R. Senior-White attending from Ceylon.

The proceedings were opened by Mr. J. Mackenna, C.I.E., I.C.S., Agricultural Adviser to the Government of India, in a short speech in which he welcomed the visitors to the meeting and dwelt on the importance of the development of entomological work in India. The Chairman, Mr. T. Bainbrigge Fletcher, Imperial Entomologist, then delivered an opening address, in which he welcomed to the meeting the many delegates from India, Ceylon, and Egypt, and explained that this meeting partook of a more formal character than the preceding ones held in 1915 and 1917, inasmuch as the scheme of holding such meetings had recently been regularized

by the Tenth Board of Agriculture in a resolution approved by Government, and that one effect of such formality would be the appointment of committees to report on particular questions and the adoption of resolutions in cases where a subject was of sufficient importance and there was a clear preponderance of considered opinion regarding it. A tribute was also paid to the memory of the late E. J. Woodhouse and C. W. Mason, two former co-workers in Indian entomology, whose deaths have occurred since the last meeting, and a formal resolution expressive of this was put before the meeting and passed in silence, all standing. The Chairman next called attention to the suggestions made from more than one direction that an Entomological Society might be formed in India, and asked the meeting for a collective opinion on the subject of the treatment to be accorded to German workers and German entomological literature in the future, and emphasized the need for some restrictions in the output of entomological literature both as regards the numbers of periodicals and the languages in which publication should be permissible. Dealing with the war in connection with entomology, he showed how the adoption of scientific methods, amongst which entomological research must be included, have reduced to a comparatively trifling proportion the preventible losses due to insect-borne diseases, and the enormous losses still due to insects in connection with military stores and foodstuffs. After pointing out how insects have anticipated the most recent developments of the "camouflage" principle and other so-called modern inventions, such as the process of paper-making from wood-pulp, he touched lightly on the subject of the control of crop-pests and pointed out the importance of an accumulation of exact records of occurrence to enable outbreaks of pests to be forecasted in the future, and then briefly reviewed the programme before the meeting.

The programme, which comprised ninety-two papers, was divided into twelve sections, each paper being read either in whole or in part or in abstract and being then open to discussion by the meeting as a whole.

The First Section was devoted to Agricultural Entomology, on which subject no less than thirty-seven papers were offered.

In a short note it is obviously impossible to mention all of these even by name. The first paper taken, on the control of insect pests, by Mr. E. A. Andrews, was not, as its title apparently indicated, a general treatise on pest control, but dealt with certain problems which were found to arise in connection with the control of particular insect pests of tea in North-East India, and emphasized that effective methods of control cannot be devised unless accompanied by a thorough acquaintance, not only with the life-history of the insect, but with its relation to the plant attacked in all circumstances, and of the behaviour of the plant under different methods of cultivation and the nature of its response to environmental conditions and to modifications of existing agricultural practices. In another paper Mr. Andrews also described the recent work done on *Helopeltis theivora*, the "Tea-mosquito" of Assam, whilst Dr. T. Shiraki, of the Agricultural Experiment Station at Taihoku in Formosa, sent a paper on insect pests of the tea plant in Formosa, many of these being identical with those found in India.

The backbone of the meeting was provided by an annotated list of general crop-pests, by Mr. T. Bainbrigge Fletcher, this comprising a list in systematic order of all insects known or reasonably suspected to cause damage to cultivated plants in India, with a short summary of our present knowledge of each insect. Specimens of the various insects had been got together beforehand in cabinet drawers, which were handed around the meeting so that all might see the insects concerned, and as each insect was brought forward the delegates were invited to add any further information regarding it, many of the papers on particular insects being taken during the discussion on these crop-pests.

The insect pests of cotton were dealt with in several papers. Messrs. Bainbrigge Fletcher and Misra gave a short account of the experiments carried out at Pusa to test the relative immunity of different varieties of cotton to attack by bollworms. Dr. Lewis H. Gough, Director of the Egyptian Entomological Service, gave a most interesting account, illustrated by lantern slides, of the work done in Egypt against *Platyedra gossypiella*, the Pink Bollworm, which was introduced into Egypt from India a few years ago and

has since proved a very serious pest. Mr. F. G. Willcocks, Entomologist to the Sultanic Agricultural Society in Egypt, also sent a very interesting paper on experiments on the survival of resting-stage larvæ of the Pink Bollworm in ripe damaged cotton bolls buried at different depths. Attacked bolls were buried at various depths in bare fallow land and in land cultivated with wheat and bersîm and, even in cases where a crop of bersîm had been grown and irrigated and finally cut, larvæ were found to have survived in the buried bolls. An experiment of this sort shows how easily these Pink Bollworm larvæ may be carried over from year to year in fallen bolls in cotton-fields in India.

Cane-borers formed the subject of a special paper. by Messrs. T. Bainbrigge Fletcher and C. C. Ghosh, in which all available information was summarized and the distinctions between the various borers pointed out.

Fruit-pests were dealt with in the list of general crop-pests and the information was also summarized by Mr. C. S. Misra in a list of the various fruit-trees with the pests of each. Mr. D. T. Fullaway sent a paper on the control of the Melon-fly in Hawaii by a parasite introduced from India ; this parasite (*Opius fletcheri*) was collected at Bangalore by Mr. Fullaway, who successfully introduced it into Honolulu, with the result that the infestation of cucurbits by fruit-flies has now been reduced by fifty per cent.

Although not strictly insects, crabs formed the subject for two papers, by Messrs. C. C. Ghosh and K. D. Shroff, on crabs principally in their rôle as pests of the rice-plant, and the discussion on these papers elicited several facts of considerable interest.

Section II was devoted to Forest Entomology, on which Mr. C. Beeson, Forest Zoologist, read a very interesting paper on some problems in forest insect control, in which he dealt with the work being done on certain insects.

Section IV dealt with Household and Store Pests and included two papers, by Messrs. T. Bainbrigge Fletcher and C. C. Ghosh, on the preservation of timber against termites and on stored grain pests. The former dealt with the experiments with various preparations tested at Pusa during the last eight years, the results

attained corroborating those obtained at Dehra Dun by Mr. Pearson. The latter gave an account of the Pusa experiments on grain storage, and it was shown that grains stored under a layer of sand remained practically immune from attack by insect pests. Mr. K. Kunhi Kannan contributed a note on the insecticidal property of mercury, in which he stated that in Mysore it is the custom to store a little mercury with grains to avert insect attack and that experiments showed that the mercury prevented pests from breeding and so acted as a protection, although its exact manner of acting was not yet understood. Mr. Ram Rao S. Kasergode read a paper on the methods of storing potatoes to prevent insect attack and gave a description of the methods found effective at Poona.

Subject V, Bee-keeping, comprised a paper on bee-keeping in India, by Mr. C. C. Ghosh. Dr. Gough also gave an account of the methods of bee-keeping in Egypt and particularly of the enemies of bees there and of the methods adopted against them. A discussion on the means of improvement of bee-keeping in India led to the passing of a resolution that, in view of the danger of the introduction into India of bee-diseases by the unrestricted importation of bees, beeswax and honey, such importation should only be permitted under necessary restrictions.

Subject VI, Lac, included a paper on lac-culture in India by Mr. C. S. Misra, and Subject VII, Silk, included several papers on sericulture. Mr. M. N. De gave a short account of the Pusa experiments on the improvement of mulberry silkworms, and also a paper on the best method of eliminating pebrine from multivoltine silkworm races. The subject of pebrine was also dealt with by Mr. C. M. Hutchinson, Imperial Agricultural Bacteriologist, who gave a most illuminating lantern-lecture on his researches on pebrine. At the general meeting the subject of pebrine gave rise to an animated discussion which was undoubtedly of benefit to all concerned. In this section also Mr. C. M. Inglis gave an exhibition of specimens and drawings of Indian wild silkmoths, whilst Mr. J. Henry Watson sent a note on the life-history of *Caligula cachara*.

Subject VIII dealt with Life-histories and Bionomics, on which twenty-one papers were communicated. Major F. C. Fraser, I.M.S., exhibited a large series of drawings showing the early stages of Indian butterflies, many of which have not been described hitherto; in a paper on night-flying dragonflies he also called attention to the fact that some species of dragonflies fly naturally only in the evening and that most of these species are of considerable economic importance as feeding largely on mosquitos. In a paper on the forms of *Papilio polytes*, Professor E. B. Poulton, F.R.S., called attention to the interesting field in research offered by this butterfly with its three very distinct forms of female, of which two forms mimic protected swallow-tails. Mr. E. A. d'Abreu gave a summarized account of his investigations on the insect prey of birds in the Central Provinces, another subject on which very little is on record in India. The subject of rearing of insects was dealt with by Messrs. Bainbrigge Fletcher and Ghosh, who gave an account of the methods used at Pusa, and by Mr. C. Beeson, who described the breeding cages and general insectary technique used for rearing wood-boring insects at Dehra Dun, and these papers were supplemented by a description by Mr. Andrews of the rearing methods adopted at the Tocklai Experimental Station. The other papers in this section dealt mainly with life-histories of Indian insects.

Subject IX dealt with the Collection and Preservation of Insect Specimens with especial reference to India, and in a long paper on this subject Mr. Bainbrigge Fletcher gave a series of hints based on twenty years' experience of collecting insects in hot climates. Dr. E. H. Hankin exhibited specimens of specially prepared glass boxes for preserving insect specimens, and Dr. D. Sharp, F.R.S., contributed a note on the importance of collecting.

Subject X, Systematic Entomology, included eleven papers, of which we have only space to refer to a few. Mr. E. Meyrick, F.R.S., contributed a sketch of our present knowledge of Indian Microlepidoptera, a subject on which he has been working for the past fifteen years, and in a lantern-lecture Captain Froilano de Mello gave an account of some Trichonymphid parasites of Indian

termites. The question of the desirability and practicability of the preparation and publication of a general catalogue of all described Indian insects formed the subject of report by a committee, whose report was approved by the meeting in a resolution endorsing the desirability of this and appointing a standing committee to take the necessary steps to carry out this project.

Subject XI dealt with Publications, the first item taken being a note by Mr. C. Beeson on the decimal method of indexing entomological literature. This led to a discussion which culminated in a resolution concerning the desirability of the adoption of a standard classification of entomological literature for India. In a paper on suggestions regarding publication of communications on Indian insects, Mr. C. C. Ghosh recommended the establishment of an Entomological Journal for India and after considerable discussion this suggestion was endorsed by a resolution passed by a majority of the meeting, but another resolution postponed any action in this matter being undertaken for the present. A paper describing the methods to be used in preparation and those employed in reproduction of scientific illustration-work was contributed by Mr. A. W. Slater, Manager of the Calcutta Phototype Company, and illustrated with figures showing the effect of correct and incorrect preparation of illustrations.

Subject XII, Miscellaneous, included any items not included in any of the other sections. In a note on plant imports, Mr. Bainbrigge Fletcher described the legislative restrictions on the importation of plants into India imposed by Act II of 1914 and the actual methods employed in working this Act. A general discussion on entomological education in Provincial Agricultural Colleges was initiated in a committee formed of all those engaged in teaching work of this kind, and a report drawn up by this committee was approved by a resolution of the general meeting, to the effect that all Agricultural Colleges should make provision for the teaching of entomology, and that the teaching should be of a practical nature. A paper by Mr. C. C. Ghosh on some aspects of economic entomology in India, in which he drew attention to the facility with which entomological subjects could be used for the teaching of Nature

study, led to the passing of a resolution suggesting that entomology should figure prominently in all courses of Nature study, that primary school readers should contain simply written accounts of common local insects, and that the help of entomological workers should be enlisted in the preparation of such accounts in readers or text-books. The subject of the organization of entomological work in India was considered by a committee which drew up a report which, after consideration of Appendix K to the Indian Industrial Commission's Report, affirmed the desirability of the centralization of entomological research work in India, but considered that the dimensions of the proposed entomological service are not large enough and that provincial staffs will be required in addition to the staff of the Central Institute. As regards the employment of these provincial staffs, whether under the local departmental authorities or directly under the Entomological Institute, there was considerable difference of opinion and there were also differences of opinion regarding the most suitable location of the Entomological Institute, but as these differences were clearly shown in the report of the committee on this subject, the report was approved unanimously by the general meeting after considerable discussion.

The meeting concluded by various speeches which elicited the speakers' views that these meetings are of very real value to the various entomological workers scattered throughout India and that, of all those held so far, this third meeting has been the most successful. Indeed, if imitation be truly the sincerest form of flattery, the entomologists may congratulate themselves on having given a lead to other workers in the matter of these sectional meetings.

A full report of the proceedings of this meeting is now in preparation and will be issued in due course.

II. THE SECOND MYCOLOGICAL MEETING.

THE Second Mycological Meeting was held at Pusa from 20th to 24th February and was attended by official representatives from the Agricultural Departments in the different provinces and

Native States, the Forest Research Institute, Dehra Dun, and the mycological staff of the Agricultural Research Institute, Pusa. In addition to these the meeting had the advantage of the presence of Capt. Froilano de Mello, Director of the Bacteriological Laboratory, Nova Goa, Portuguese India, and of Mr. A. C. Tunstall, Mycologist to the Indian Tea Association.

The meeting was opened by Mr. J. Mackenna, C.I.E., I.C.S., Agricultural Adviser to the Government of India. In his opening speech Mr. Mackenna extended a hearty welcome to all visitors to the meeting and said that mycology was a branch of agricultural science which was still something of a mystery to the cultivator and the general public. However, there were now many cheap and effective remedies against fungal diseases of which the success and popularity of the steeping of *jowar* (*A. Sorghum*) seed with copper sulphate, as a preventive against smut, was a striking example. Since the last meeting an event of considerable importance to mycologists had been the publication of Dr. Butler's book on " Fungi and Disease in Plants."

In introducing the subjects for discussion Dr. Butler said that the Second Mycological Meeting was being held under a somewhat more definite constitution than on the last occasion, since the policy of holding sectional meetings, advocated at the last meeting of the Board of Agriculture, had been accepted by the Government of India. He thought that the attention of the present meeting should be directed to the more important mycological problems in India and, in view of the present economic crisis in the world's food-supply, that they should concentrate as far as possible on the major diseases of food crops and the means of combating their ravages.

In this connection he would like to call attention to the work of the War Emergency Board of American Plant Pathologists. This body was formed a little over a year ago with the object of stimulating and accelerating phytopathological work in America, to the end that, in this present world crisis, the reduction of crop losses from diseases should be made most effective as a factor in the increase of our food supply. Of the extent of those losses the

following figures compiled by the Board for the United States alone in 1917 gave some indication :—

Wheat	...	...	...	64,440,000	bushels.
Rye	...	...	...	2,685,000	,,
Barley	...	...	...	12,252,000	,,
Oats	...	...	...	153,973,000	,,
Maize	...	...	...	175,344,000	,,
	Total cereal loss		...	408,694,000	,,
Potatoes	...	...	...	117,174,000	,,
Beans	...	...	...	2,528,000	,,
Sweet potatoes		...	...	41,707,000	,,

And this was in a year which was not an especially bad one as far as diseases were concerned. These estimates had been most carefully framed and were said to be the most reliable that had ever been made. Had oat smut been completely controlled (and they all knew that it could be so controlled), the amount of this cereal exported to the allies and neutral nations could have been almost doubled, while twice as usual maize was lost from smut as was exported. In India the losses due to plant disease were at least equal to those recorded elsewhere. Thus in Bombay Presidency alone the losses from smut of *jowar* were estimated at one million sterling annually—a loss which it was quite feasible to control.

At the conclusion of Dr. Butler's speech the meeting passed a resolution expressing its gratitude at the generous offer of assistance received from the War Emergency Board and welcoming the opportunity of co-operating in mycological work with the scientists of an allied nation.

The meeting then proceeded to the discussion of Subject I—a survey of the diseases of plants in the different provinces. Under this head it was decided to consider, one after another, the major crops and their fungal diseases.

The storage rots of potato first occupied the attention of the meeting. The importance of a proper method of storage was insisted upon by many speakers. The experience of the military authorities in India, and the shortage of potatoes in Germany during the first year of the war, alike illustrated the essential character of this point. In India a private firm in Poona had set up an efficient system of sorting, fumigating and packing seed potatoes

for Mesopotamia, a work in which they had been greatly helped by the mycological staff at Poona.

There was some discussion on the incidence of ring disease, scab and other fungal troubles of the potato and the meeting then passed on to the consideration of diseases of cereals.

Among cereal diseases one of the most important for India was smut of *jowar*. This disease could be completely controlled by seed steeping in a solution of copper sulphate and a great deal of time and energy was being expended by the Departments of Agriculture in Madras, Bombay, and the Central Provinces in spreading this treatment among the cultivators. In Bombay alone 40,000–50,000 one-anna-packets of copper sulphate were sold annually. In fact, as one member of the Bombay Agricultural Department expressed it, "the district agricultural officers go out into the countryside to spread the gospel of agricultural improvement bearing an iron plough in one hand and a packet of copper sulphate in the other." The rust and smut diseases of wheat caused a considerable amount of loss in all parts of India and the introduction of resistant varieties of wheat was evidently one of the most promising lines of work. A variety of Australian wheat called Federation had been introduced at Peshawar and was found very resistant to both smut and rust. The varieties Pusa 4 and Pusa 12 were also resistant to rust, although the former was susceptible to smut in Peshawar. It was evident that the problem of rust-resistance in wheat was one which varied in different localities. For a country the size of India it did not appear likely that wheats bred in any one centre would be resistant to rust throughout the whole continent.

The most important Indian cereal—paddy—was fortunately very free from serious fungal diseases. An epidemic of "blast" had occurred locally in Madras during one season but had not re-appeared since.

The meeting next discussed diseases of sugarcane. The most important disease was red rot. In Madras a method of stool selection had given excellent results and had reduced the infection to 1 per cent. On Pusa Farm only set selection had been practised and by this method the disease could not be reduced below 10 per cent.

Smut of sugarcane, although a disease of minor importance, was of great scientific interest as the method of infection had just been discovered at Pusa.

Other crops which were discussed were gram, chillies, cotton, jute and others. In the case of the wilt disease of gram and pigeon pea the results now being obtained from the permanent manurial experiments on Pusa Farm were of great interest. It was becoming apparent that the incidence of wilt in pigeon pea was considerably influenced by the manurial treatment. Chilli diseases were very common in Bihar and experiments at Pusa had shown that a great deal to control them could be done by spraying.

The first day's session terminated at the conclusion of this discussion on the major crop diseases.

At the second session the meeting discussed Subject II, the proposal to form an Imperial Bureau of Mycology in England with special reference to the directions in which the Bureau might be useful to colonial and Indian mycologists. During this discussion it was evident that all members of the meeting were in agreement as to the very real need for such an institution. Previous to the outbreak of war, mycologists in India and the colonies had been largely dependent upon foreign countries for assistance in certain branches of their work. This assistance had in the case of enemy countries been cut off during the last four years and it was now impossible to resume the old relations. It was agreed that the duties of the new Bureau should be :—

(1) to organize a system for the prompt identification of all injurious fungi for Departments of Agriculture and other similar bodies;

(2) to publish a periodical for summarizing current literature on plant diseases, British and foreign;

(3) to prepare and keep up-to-date classified lists of references to the past and present literature of the subject, and to establish a library;

(4) to answer enquiries from plant pathologists.

The meeting was also in favour of the laboratories of the Imperial Bureau of Mycology being open to such colonial and Indian

mycologists as were desirous of carrying out mycological research during their periods of leave. At the same time the meeting emphasized the importance of research work in colonial and tropical phytopathology being done on the spot, and held that it would not be desirable for the Imperial Bureau of Mycology to engage directly in research work, other than work of systematic nature, on tropical diseases. At the conclusion of this discussion Mr. Mackenna asked that in view of the importance of the subject a copy of the minutes might be forwarded to him for submission to the Government of India.

The meeting next considered Subject III, the spraying of crops. Interesting accounts of the spraying of tea in Assam, vines in Bombay, areca palm in Madras and Mysore, and fruit orchards in Peshawar and Kumaon were given to the meeting by the members interested in the subject. From a financial point of view the spraying of vines in Bombay Presidency was perhaps the most successful instance. Spraying had in this case made the vineyard a certain source of large profit to the owner, whereas it had formerly been a risky speculation. All who had had experience of spraying in India during the last few years agreed that the difficulty in obtaining sprayers and their high prices had been limiting factors in the extension of spraying. The successful manufacture of sprayers in Mysore was a matter of great importance and it was generally regretted that these sprayers were not yet open to purchase by the public.

The formal session on the second day terminated at this point and the members spent the remainder of the day in the mycological laboratory examining specimens and seeing such research work as was in progress. In the evening Capt. Froilano de Mello delivered a lecture on Medical Mycosis. Captain de Mello's account of human diseases of fungal origin opened up a new, and fascinating, branch of mycology to most members of the meeting. An excellent series of lantern slides illustrated the lecture and the fortunate discovery by Capt. de Mello that several members of the menial staff possessed, on their persons, excellent examples of dermatomycosis enabled him to give a demonstration in laboratory technique.

The third session opened with the discussion of Subject IV—diseases of planters' crops.

In discussing the organization of mycological research for planting industries the meeting considered the system in vogue in the Federated Malay States where a large plantation was run as an experimental station and the profits were utilized towards scientific research. In the Federated Malay States such experimental stations yielded a profit which nearly met the cost of the local Agricultural Department. The meeting generally agreed that this system was excellent, provided that there was no attempt on the part of Government to subordinate the research interest to profit making.

After a detailed consideration of the various diseases of coffee, tea, and rubber, the meeting proceeded to discuss Subject V—mycological education in provincial colleges.

The representative of each province in turn gave the meeting a brief account of the standard of mycological education in his Provincial Agricultural College.

Apart from the official courses in mycology in the Agricultural Colleges an interesting new departure was the attempt to establish a mycological class for "estate writers" at Coimbatore. The object was to train Indians from rubber estates to carry out plant pathological observations and plant sanitation on the plantations where they were employed. These courses had been running for two years and were very successful. After training, the men were placed in charge of "pest gangs" on the estate and were responsible for operations against fungal diseases. The vernacular course in sugarcane culture and the course in arboriculture at Poona, were other instances of this type of instruction.

The meeting was greatly interested in an exhibit of models of plant diseases which were used in the courses at Coimbatore. These models, which were superior to anything imported from Europe, were made locally and there was a general desire that arrangements might be made so that such models could be purchased by other colleges.

The lack of mycological education in Indian Universities was generally regretted by the meeting. It was considered that

such education as existed was of a type which attached too much importance to a mere book knowledge of European types and laid too little stress on the necessity for a knowledge of Indian fungi.

The last matter discussed was Subject VI—the application of genetics to the control of plant disease. The meeting considered that this subject was one which offered peculiar scope for development in India. It was pointed out that in Europe the efforts of generations of nurserymen engaged in breeding new varieties of plants for commercial profit had resulted in the more or less unconscious selection of disease-resistant races. Thus there was a relatively restricted field for the scientist. In India, however, the crops had not been the object of improvement by nurserymen and therefore more rapid results might be expected than could be obtained in highly civilized countries. Wheats which were more or less resistant to rust had already been bred at Pusa and a very resistant Australian wheat had been introduced at Peshawar. The meeting agreed that, while the application of genetics to the control of plant disease was a matter at present scarcely developed in India, each member should note during the next two years any direction in which it appeared that this method could be utilized and should bring up the case for discussion at the next meeting.

This concluded the formal proceedings of the meeting. A small committee sat later to consider diseases of rubber and in the evening Mr. Kulkarni gave a lantern lecture of the type which he was in the habit of delivering to cultivators in Bombay. Mr. Kulkarni explained how he kept the attention of his audience by enlivening the details of fungal diseases with lantern slides showing scenes from Europe, pictures of cattle, steam ploughs, etc., which would be likely to interest the ryots.

The proceedings terminated with an informal meeting in the Mycological Section, on 24th February, for the discussion of matters of laboratory technique and an exhibition of spraying machinery.

A detailed report of the proceedings will be issued in due course.

III. THE FIRST CHEMICAL MEETING.

The first meeting of Agricultural Chemists and Bacteriologists in India was held at Pusa from the 24th to 28th February, 1919, under the chairmanship of Dr. W. H. Harrison, Imperial Agricultural Chemist. It was attended by the Agricultural Chemists of all provinces, and also by Mr. W. A. Davis, Indigo Research Chemist, Mr. C. M. Hutchinson, Imperial Agricultural Bacteriologist, and Mr. R. D. Anstead, Deputy Director for Planting Districts, Madras. The meeting was opened by Mr. J. Mackenna, C.I.E., I.C.S., Agricultural Adviser to the Government of India, who welcomed the delegates and emphasized the value of such meetings in relation to the future development of the investigation of Indian agricultural problems.

There were ten subjects down for discussion. These may be broadly stated as follows:—

(1) References from the Government of India.

(2) Consideration of facilities for the development of industrial problems arising out of the successful researches of Agricultural Chemists and the provision of specialized laboratories for the investigation of problems of general importance.

(3) Questions regarding the Service of Agricultural Chemists, their duties, and the technique of their work.

(4) Post-graduate teaching in agricultural chemistry at Pusa.

(5) Bacteriological subjects.

It will be remembered that the Board of Agriculture in India, at its meeting held at Poona in 1917, passed a resolution that in its opinion the time had arrived when some form of legislation was necessary to regulate the sale of fertilizers in India in order to protect both the planting industries and the Indian cultivator. The Government of India requested the meeting to frame a draft Fertilizer Act applicable to Indian conditions. This was accordingly done, the Fertilizer and Feeding Stuffs Act in force in the United Kingdom being taken as a model and suitable modifications made therein. The other reference from Government for detailed consideration was Resolution VIII of the same Board dealing with the question

of reducing the present railway freight for the carriage of manures. To any one acquainted with conditions in this country, the importance of increasing the use of concentrated manures as a part of the general agricultural development of the country is obvious. Among the causes which operate against the extended use of the manures is the fact that manures have to be carried over long distances from the centres of supply to make them available to cultivators. Further, the demand of the individual cultivator is mainly for small consignments of manure, and in view of the caste prejudices prevalent in the country many fertilizers, such as bone-meal, dried blood, and poudrette, are classed by the railway companies as offensive goods. Again, there is no uniformity in the rates charged at present by the various railways for the carriage of manures. After a due consideration of the various difficulties it was resolved that the Railway Board be asked to arrange that the present minimum rate of 1/10th pie per maund per mile should be charged in all cases on minimum waggon loads of such concentrated manures, and that the Provincial Agricultural Departments should encourage the formation of local distribution centres so as to build up a regulated traffic which is capable of taking full advantage of the concession of the minimum rate.

It very often happens that the research work of an Agricultural Chemist or Bacteriologist leads up to a problem of industrial importance which he is obliged to give up because there is no suitable technological laboratory for carrying it to a successful commercial issue. The work done on malt extracts in the Coimbatore laboratory, and on saltpetre, indigo, etc., at Pusa, are instances in point. The creation of a technological laboratory as one of the special sections of the Imperial Agricultural Department under the Government of India where such subjects of industrial importance can be carried to a successful commercial issue was therefore recommended by the meeting.

There are again numerous problems which though not directly industrial are still of great importance in connection with agriculture. Among such problems requiring immediate consideration are, (1) animal nutrition, (2) soil physics, and (3) vegetable biological

chemistry, but there are neither specialized laboratories nor suitable staffs to undertake this work. The meeting recognized the need for the provision of such laboratories with separate staffs under the Government of India for the investigation of such problems of general application. It was felt that the location of these laboratories should be determined by the particular requirements, as regards, for instance, the need for collaboration of their staffs with other departments, sections, climatic and other conditions and they need not necessarily be at Pusa.

The proposal made in the Report of the Indian Industrial Commission for the formation of a Chemists' Service was not accepted by the meeting mainly because intense local knowledge is required for effective work for agricultural improvement by chemical methods, and it is not desirable that the Chemists in the Agricultural Departments should be formed into a Service apart from the Indian Agricultural Service, in which the bond of union would be the Science rather than its application. On the other hand the meeting was definitely of the opinion that in addition to the Agricultural Chemists attached to the Provincial Departments a strong central body of chemists should be maintained by the Imperial Department of Agriculture from whom Provincial Departments can draw for the investigation of special problems.

With the rapid expansion of chemical investigations in the provinces it has become necessary to relieve the Agricultural Chemists of the teaching work so that they may be enabled to devote more of their time to research work. The meeting, therefore, recommended duplication of the chemical staff for the adequate pursuit of research and teaching. In the opinion of the meeting the duties of the Agricultural Chemist as opposed to the Professor of Chemistry should be primarily limited to the research and executive side only, giving such assistance in teaching as may arise out of his research and which fits in with the college course. The teaching officers should also be given opportunities to engage in research work.

The meeting next considered the question of soil surveys. It held that soil surveys throughout this country would be of undoubted value not only in cases where new lands are in question but

also for general application as a means of obtaining information as to the relationships between climate, soil, and crop. The necessity of standardization of methods not only in the case of such surveys but also in the analysis of soils and other materials was recognized and important recommendations were made.

The question of post-graduate teaching in agricultural chemistry at Pusa and the class of student to be admitted to this advanced course was then considered. It was resolved that the teaching should be strictly directed to instruction in the various specialized branches of agricultural chemistry and that the students to be admitted to this course should be either graduates of an Agricultural College, or Science graduates of an University who have attended a Provincial Agricultural College for at least a year and are recommended for further training in agricultural chemistry by the Agricultural Chemist.

A day was specially set apart for the consideration of bacteriological subjects. The necessity of providing for the proper study of soil bacteriology by the Agricultural Departments in India was recognized, a full discussion of provincial conditions having revealed an urgent demand for the investigation of bacteriological problems either connected with the soil or with agricultural industries. It was accordingly recommended that Local Governments should consider the desirability of adding an Agricultural Bacteriologist to their scientific staff.

The question of the standardization of methods of biological analysis of soils was also considered in detail.

Detailed proceedings of the meeting will be published in due course.

"WATER SAVING" EXPERIMENTS.

BY

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THE main factors chiefly affecting the yield of crops per acre are the amounts of water, labour and manure put into the land. Theoretically, the farmer's problem everywhere is to use that amount of water, labour and manure per acre, and to use them in the way which will produce him the greatest profit per acre. But, practically, owing to their varying availability and cost, the relative importance of these several factors in crop production varies enormously from place to place, and it is rarely that all are simultaneously of great importance. The amount of water used is only of importance where the supply is limited and controllable. This is the case in irrigation farming in a dry climate. Here in reckoning profit per acre we must consider not only the rental value of the land, and the cost in labour and manure, but also the water-cost of the crop. When the climate is very dry and the water-supply is strictly limited or very expensive, then the water-cost becomes the item of greatest importance on the debit side of the balance-sheet. Such circumstances exist in parts of Northern India, the west of North America, and in many other countries. The object of the present paper is to indicate the lines on which the study of the water-cost of crop production should be taken up in India. The need for this work is obvious to everyone conversant with agricultural matters in Northern India, and was recognized by the Board of Agriculture at its 1917 meeting.

The factors affecting water-cost.

The water-cost of producing a certain weight of any crop per acre depends on some matters practically beyond the control of the farmer, such as the climate and the mechanical composition of his soil. But it also depends on the following matters which are to some extent within his control:—

(1) The irrigation given: not only the total amount of water used for the crop, but also the depth and frequency of the waterings at different stages in the growth of the crop.

(2) The richness of the soil in available plant food.

(3) The physical condition or tilth of the soil at the time of sowing.

Both of these (2 and 3) depend on the rotation which has been followed, and the manure and cultivation given.

(4) The way in which the water is applied—whether by flooding the whole field or applying it only in furrows; the size of *kiaris*,* etc.

(5) The extent, and frequency, etc., of subsequent cultivation by harrowing or interculture.

(6) The botanical variety of the crop selected for sowing.

(7) The seed rate or number of plants per acre.

Our present knowledge.

Some work bearing directly on this matter of water-cost of crops has been carried out in Europe and India; but very much more has been done in America by a considerable band of workers—King, Widstoe, Briggs, Fortier and many others. The American work has received curiously little attention in India, possibly because the results have only recently been mentioned in text-books. Naturally the American results are not quantitatively applicable to India; in fact, even qualitatively, they need some amplification and confirmation for Indian conditions. But enough has been done in America to show that no field of investigation in

* Compartments used in the Indian method of irrigation.

India is likely to repay study more quickly or fully. And enough has been done to indicate the relative importance of the factors which have been outlined above. The American work has shown that the order of importance of these factors, in regard to the degree to which they affect water-cost, is the order in which they are given above, and that the former three are of vastly greater importance than the latter four. In the present paper attention is given to the first three factors only, because they are most important, their consideration logically forms a basis for future work, and these three factors are all intimately connected, and must be studied together.

THE IRRIGATION GIVEN.

Problem 1. *The relation between frequency of irrigation and the stage of growth of the crop.*

It is frequently stated that zemindars are in the habit of over-irrigating their crops. Experience in the Punjab leads the writer to believe that this is frequently not true in regard to the critical periods when the needs of the crop are greatest. But there is a distinct tendency among zemindars, both on wells and canals, to irrigate with approximate uniformity throughout the life of the crop. Yet the water requirements of plants are known to be very different at different stages, the transpiration rate at its greatest being often ten or even twenty times more than at the beginning or end of the period of growth. Thus it is possible that the irrigation can be greatly reduced at certain stages, with little or even no effect on the final yield. To put the water so saved to useful purpose may not always be easy where there are no reservoirs,[1] and this in turn will need to be considered. (It is probably the difficulties in this respect which have deterred zemindars from paying more attention to such saving.)

Conversely it is possible that yields might be increased by more irrigation than is now sometimes given during the critical time when the need is greatest.

[1] Roberts, W. and Faulkner, O. T. "Some factors affecting the efficiency in the use of canal water." *Agric. Journal of India*, Special Science Congress Number, 1918, p. 81.

Instances of these possibilities in the Punjab may be cited in regard to the wheat and cotton crops. Our experience and experiments at Lyallpur show that the needs of the wheat crop for water are very much greater during a period of six or eight weeks than during the remainder of the time the crop is on the ground. There is still much room for investigation even on this point; but, roughly, the period when the need for water is greatest is from about the time of the "shooting" to that of the "yellowing" of the stalk. That is generally from some time in early February till late in March. Thus experiments carried out some years ago at Lyallpur,[1] and repeated experience since then, have shown that, in case of fields which have previously received at all adequate irrigation, a watering in April, such as is frequently given by zemindars, does not increase the yield of the crop. Again, wherever heavy wheat crops have been grown with very little irrigation, as in our experiments at Lyallpur, the figure for quantity of water applied has been reduced by withholding irrigation except during the period referred to.

Similarly, in the case of cotton in the Punjab, it is evident that the crop can grow with much less water during its early life in May, June and at least the early part of July, than it needs during a period of some eight weeks from late July till about the end of September or early October. All that can be said at present is that good crops have been obtained in spite of greatly reduced irrigation during the earlier growth of the plant. But again the relation, on different soils, between the irrigation given at different stages and the final yield, awaits and merits investigation.

For if, as appears to be the case, the needs of the cotton-fields for water are much less during the hot weather than during the monsoon months, then larger areas of this crop can be sown with prospects of success if there is a fair monsoon. But if the monsoon fails, and the maintenance of a comparatively high water content in the soil during these months is as important as appears to be possible, then it might conceivably pay to concentrate the

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[1] *Experiments, etc., at the Agricultural Station, Lyallpur, Punjab.*

available water on the best fields, in spite of the failure of the worst.

This matter has also an important bearing on the design of inundation canals, and on the question, which has recently been raised, as to the advantages of high *kharif* (summer) supply capacity on perennial canals.[1]

Problem 2. The best depth of water to apply at one time under varying conditions of soil, season and crop.

The ideas of zemindars on this subject are not at all definite; in the main, their practice seems to be usually to apply as little as possible at once; but the actual amount varies very greatly and depends chiefly on the condition of the soil at the time of watering, and the rate of the water-supply. A little consideration will show that a simple answer to this question cannot be given off-hand. When irrigation water is applied to a dry soil, it quickly percolates to a certain depth, which will be of the order of about one foot per inch of water applied. After this it only moves down more slowly and in lesser quantity. The rate will always vary according to the texture of the soil. Obviously to reduce the losses in this direction to a minimum, the irrigation should be as light as possible. A uniform moisture content is the ideal condition for the growth of plants: this will be more nearly attained by giving frequent small irrigations. But on the other hand the loss by evaporation from a recently irrigated soil is known to be very rapid in a hot climate—much more rapid, for instance, than the evaporation from a still water surface. It is possible that this loss may at times be equivalent to more than one inch of water in the first three days after irrigation.[2] Evidently there is a possibility of considerable economy from heavier and less frequent irrigations. The best amount to apply will thus be that quantity which effects the best possible compromise. This amount will depend on the time of the year, the presence or absence of a crop, the stage of growth of the crop, and, of course, on the

[1] Roberts, W. "Extension of American cotton in the Punjab." *Report of the Punjab Engineering Congress*, 1918, p. 1.

[2] *U. S. A. Office of Experiment Stations Bull.* No. 248, p. 14.

nature of the soil. American experiments give us little assistance in this respect, and we must find out the best depth of watering for ourselves.

But it is not enough to know only what is the best amount to apply: it will often be equally desirable to be able to form some idea of the loss that will result from applying more or less than this amount. For at times when water is available in excess, it may well pay to incur some loss through excessively heavy irrigation, in order to delay the necessity for the next irrigation. One case where this might apply in the Punjab, in some years, is in the *roni* * irrigation for early sown *toria* (*Brassica campestris*). Again wheat-fields in the Punjab frequently do not require irrigation, after sowing, until February; but it might pay to give heavy waterings to some fields in January in order to allow of a delay in the next (February) watering. In some years it may pay to give heavy *roni* waterings in the early wheat-fields, in order to ensure that the first watering after sowing (*cor*) will not be needed until all sowing is over. Frequently, on account of attack by white ants, the early sown wheat-fields have to be watered again in November or early December, which interferes with sowings.

Problem 3. *The relation between total irrigation and yield.*

This is a question of the greatest importance not only to farmers but also to Government in its control of rivers, canals, and reservoirs, and it is the problem in irrigation which has received most attention in America: this is practically the only fundamental problem of irrigation farming in India which has received any attention experimentally. In the Punjab some useful and systematic field experiments were carried out by the Canal Department.[1] These experiments only dealt with the wheat crop. From the farmers' point of view, these experiments are less useful than from the engineers'. For before the yields of the different plots in such experiments can be exactly applicable to farming practice, it is evident that the different amounts of water compared must each be distributed

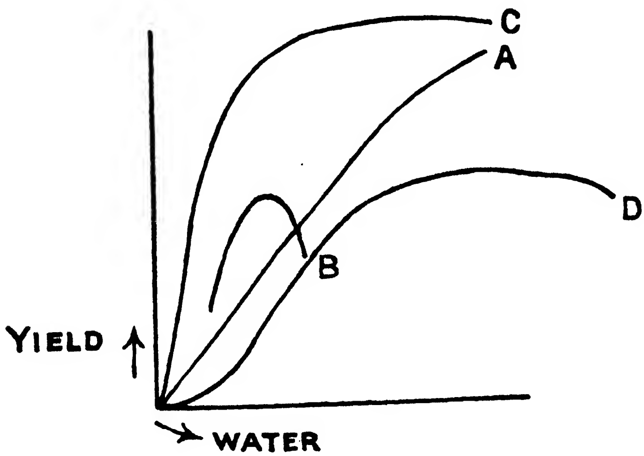
* The watering given just before sowing.

[1] *Punjab Irrigation Branch Papers*, 1904–08, pt. III.

throughout the life of the crop in the best way practicable. Of this no one has yet been in a position to judge.

In order to explain the prevailing ideas on this subject we may deal with the wheat crop which has been most studied from this point of view, and must, for the present, express the total quantity of water applied to the crop in the very crude form of "number of waterings including that just before sowing," and neglect rainfall which may replace part of the irrigation.

The zemindars' idea seems to be that, within any reasonable limits and if properly applied, "the more water the more yield," *i.e.*, that the shape of the curve is something like the line A on the diagram.



Mr. A. Howard[1] apparently considers that the shape of the curve is like the line B, with the maximum at about two waterings and with a fall immediately beyond this point, due to lack of soil aeration as a result of excessive watering. The only experiments justifying this conclusion seem to be those near Buchiana which gave the following results :—

	Gungapur	*Haripur*
One watering	**12½ mds.***	**8¾ mds.**
Two waterings	**18 „**	**15¼ „**
Three waterings	**14¾ „**	**16½ „**

*** 1 maund=82 lb.**

[1] **Howard, A.** "**Recent investigations on soil aeration, with special reference to agriculture.**" ***Agric. Journal of India*, vol. XIII, pt. III, p. 426.**

Now the first experiment was carried out on good soil, yet the highest yield is only 18 maunds. In the same year, on land which is not better than that used in these experiments, we had yields of 30 maunds in spite of applying no less than four waterings. It would thus appear that the low yield obtained from three waterings is not entirely due to an excessive number of waterings. General considerations of the processes of plant growth in soils, the numerous experiments on this point in America, the experiments at Lyallpur and many observations on well and canal lands, the experiments conducted by the Punjab Irrigation Department, all these indicate that the shape of the curve is something like the lines C and D in the diagram. At first, as the quantity is increased, the yield rises rapidly to a certain point. In the case of wheat grown on average well cultivated land in the Punjab this point represents a production of at least 25 maunds of grain on a total water-supply of about 12 in., of which some is usually in the form of rain. On poor or ill-cultivated soils the maximum yield will be less and will need more water. The curve must therefore be something like the line C or D according as the field is good or poor. (See *also Problem* 4, *infra.*)

Beyond the maximum, the yield remains practically constant in spite of great increases in the irrigation. Presumably a point could be reached where the yield is decreased through some secondary factor due to over-watering. But the author has not seen any reliable results from field experiments definitely to support the statement in regard to the wheat crop. There is no doubt that the irrigation would have to be very heavy or very ill-advisedly applied to have this effect.

Problem 4. *The relation between the richness of the soil and the water-cost of crops grown on it.*

Problem 5. *The relation between the tilth of the soil and the water-cost of the crop grown on it.*

Roughly, the practice of zemindars is to irrigate all fields to much the same extent. Any deliberate distinctions drawn are on

account of differences in mechanical texture or on account of alkalinity in the soil—not because of differences in amount of available plant food or in tilth. Yet it can often be predicted that two neighbouring fields will give enormously different yields simply on account of their temporary fertility; and it would seem possible that it might pay to give different total amounts of water to these fields. Yet it is probable that as a rough and ready compromise the zemindars' practice is not far wrong. For on the one hand it would seem that the rich, well-cultivated field capable of giving a heavy crop will better repay ample watering. But, on the other hand, it is well known that the water-cost of the same weight of crop decreases within wide limits as the plant food available in the soil increases; so that on this account the poorer field should receive more water. The effect of differences in tilth on the water-cost of the crop has not been so exactly investigated, but there is no doubt that the same statements hold good with regard to that too. These points however need thorough investigation, for they are of great practical importance.

The experiments suggested.

The principles underlying the solution of these problems may be elucidated by pot experiments, studies of field moisture contents and laboratory investigations. But in India we also need data sufficiently reliable, quantitatively, to justify exact and definite recommendations to zemindars or to canal authorities. Such data can only be obtained from very carefully conducted, practical, and amply repeated plot experiments, in which water is given to the different plots in varying amount and with varying frequency. It is evident that such experiments will have to be repeated on soils of different mechanical composition. Sufficient elaboration in this respect should not be impossible; for observations indicate that small differences in mechanical composition in soils do not cause great differences in the water-cost of crops grown on them. But the experiments must be repeated on the same soil in very different states of tilth or temporary richness in plant food, and also with varying content of organic matter. If the experiments are to be

conducted on practical lines, this means that they must be repeated on neighbouring fields cropped under systems of varying intensity and manurial treatment.

The question of intensity of cropping is of one of the greatest importance in irrigation, and must be shortly considered here.

INTENSITY OF CROPPING.

Although the matter needs much more scientific investigation, yet anyone who studies irrigation farming in arid climates, must appreciate that fallowing and manuring are here, within rather wide limits, practically alternative methods of enriching the soil. This is everywhere recognized as being true to some extent; but it would seem to be true to a much more remarkable degree in such a climate as that of Northern India than in a more humid and cooler one. Maximum crops, even of quick-growing plants, like sugarcane, can be grown without manure, if the land has been fallow for a very long while. An extreme instance of this is the heavy crops of thick cane grown on the recently cleared land of the Lower Bari Doab Canal Colony in the Punjab. And it must be the comparatively low intensity of cropping (about 100 per cent.), and the thorough cultivation on the Lyallpur farm, which accounts, at least in part, for the frequent failure of manures there to give such results as might be expected.[1] On the other hand, though experiments in manuring combined with high intensity of cropping have only just been started, the effect of farmyard manures, and the residues of a leguminous crop, etc., can frequently be observed to have remarkable effects under such circumstances. This seems to be especially true in regard to *kharif* crops such as cotton and maize. There can be little doubt that by suitable rotations, combined with manuring, fallowing may be reduced to a minimum and the intensity raised to about 150 per cent. And, further, it would seem that, if high yields are to be obtained by manuring, a high intensity of cropping must be adopted. For it cannot be profitable to have

[1] "The value of phosphate manures in India and the possibility of their manufacture on a larger scale." *Pusa Agric. Res. Inst. Bull.* No. 81, p. 9.

rich manured land lying fallow, earning nothing, and possibly suffering losses of its humus content through oxidation or denitrification. This fact is reflected to some extent in the practice of many Punjab zemindars, who concentrate their manure on a portion of their lands, and crop this portion more intensively. On the other hand, under a high intensity it is difficult to retain good tilth in the soil, for there is less time for cultivation and fallows are shorter.

This matter of the efficiency of different intensities of cropping is well worth extended investigation: its importance in connection with canal construction and working is obvious.

A necessary corollary of higher intensity of cropping will almost certainly be an increase in the areas of fodder crops, which will be utilized for increased cattle-rearing and possibly, in the future, far more dairying. Thus the necessary higher supply of manure will be provided for, whilst the fodder crops will rotate with the main crops and occupy the land in the intervals between them. As the fodder crops will be partly legumes, they will not greatly increase the strain on the supply of nitrogen in the soil, and they would prevent any losses in water or humus, which may occur when a rich soil is lying fallow.

The question of the most efficient cropping of irrigated lands depends on many considerations, some of which are outside the scope of this paper. But the water-cost of the produce from the different systems must be the first consideration on which others are based. The experiments suggested in this paper will provide the necessary data for the consideration of the economic and engineering, as well as the farmer's, aspect of these problems.

SCHOOL GARDENS.

BY

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"THE scheme of primary and secondary education for the average scholar should steadily, as trained teachers become available, be diverted to more practical ends, *e.g.*, by means of manual training, gardening, outdoor observation, practical teaching of geography, school excursions, organized tours of instruction, etc."—[*Resolution of the Government of India, 1913.*]

This extract from one of the most important State Papers of recent years points to an ideal which is still in the distant future, and the steps which are being taken to lead to it are, as yet, slow and halting. There were many school gardens in existence before the date of this pronouncement, and since that date successive conferences of agriculturists have given expression to the widely held view that Nature study should form a necessary part of the curriculum in rural schools and that a garden should be attached to schools as an aid to Nature study. Yet there has been, so far as I know, no organized effort to provide either teachers of Nature study or gardens. The Education Department in my own province, and I believe elsewhere also, has been supine in the matter and local bodies and their officials in whose hands the initiative lies have not had their attention prominently called to it. Yet there are vast possibilities in Upper India where nearly every family has some connection with the soil, where village school teachers are nearly all drawn from the rural population, and where land in the vicinity of village schools can generally be easily obtained. It is

in order to familiarize the public and local authorities with the subject and to encourage the organization of school gardens as an essential factor in a true rural education that this article has been written.

OBJECTS OF THE GARDEN.

The objects of gardening in schools may be said to be—

(1) to beautify the surroundings of the school;

(2) to limit expenditure on school buildings;

(3) to introduce an agricultural atmosphere into the school;

(4) to interest parents, school committees and the public in the school as a village institution;

(5) to stimulate in the neighbourhood interest in new vegetables, crops and varieties and to introduce to the locality such as may be found suitable;

(6) to inculcate in boys' minds the dignity of labour and introduce them to the spirit of service for the community;

(7) to emphasize the importance to be attached to agriculture; and

(8) to provide examples for the teaching of geography, arithmetic, mensuration and kindred subjects and material for Nature study.

A few remarks may be made in explanation of these objects. I take the first two objects together. A bare whitewashed or red-brick school on a bare maidan, such as is still frequently seen, is obviously likely to be an excrescence on the life of the village rather than a village institution in which the residents can take pride and pleasure. There is no protection from the sun and hot winds of summer, nor from the cold winds of winter except in the school itself, and therefore a large building is required. With a well-grown garden, boys can sit outside in the sun or in the shade according to the time of year, and even in the rains under light sheds constructed for the purpose. There will then be no need of extension of school buildings to meet an increased attendance. All that is required is a small but a substantial building where the school effects can be

suitably housed, and where charts, maps and pictures and objects for drawing lessons can be displayed on the walls and shelves, and which would be a nucleus in and round which the boys would be collected for work, play and drill.

With the expansion of primary education, which is now taking place in all provinces, large sums are being spent on extensive buildings for central schools. It is submitted that large buildings are not needed, that the money had far better be spent on enclosing and laying out of gardens and the construction of wells and teachers' quarters.

Thirdly, the central and all-absorbing interest of an Indian village home is agriculture : ploughing, sowing, weeding, manuring, watering and reaping of crops and the tending of cattle. It is these occupations with which the boy is familiar, and which will take up his time in future years. But in the school he is in another atmosphere altogether—an unreal atmosphere of books and paper and sums which have little and sometimes no connection at all with his home experiences. His work in school is in no way correlated with his life out of school. It cannot therefore arouse his intelligence, or be made interesting to him, and cannot therefore be an adequate preparation for his life's work. As an American writer says : "Any form of education, to be effective, must reflect the daily life and interests of the community in which it is employed." Hence the necessity for the introduction of an agricultural atmosphere.

Fourthly, working parents seldom believe in the utility of education for their sons, and this is particularly true of agriculturists who work with their hands. If they keep their sons at school, as they seldom do, after the age at which they begin to be useful in the fields, it is with the idea that they may, by acquisition of knowledge, be able to secure some literate post and draw a cash salary, however small, to help the family budget. They do not conceive that a boy, who is destined to carry on the family occupation of agriculture, will get any benefit from schooling. On the contrary, they fear that he will acquire a distaste for agriculture and habits which will unfit him for hard physical work in the field.

The best means, therefore, of making rural education popular is to interest the general body of villagers, who also comprise the parents of the boys in the school, by showing that it is not antagonistic to agriculture, but on the contrary tries to assist it. How it does so, is shown in the next paragraph.

The *fifth object* is to stimulate in the locality interest in new vegetables, crops and varieties, and to introduce to the neighbourhood those found most suitable. In practice what can be done is to obtain from the Agricultural Department or elsewhere seeds of new vegetables, crops and varieties, and to raise produce from them in the gardens. The work is similar to that undertaken by demonstration farms, but it is not called demonstration, because methods of cultivation may be faulty or the locality may not be favourable, and so the crop may not be successful, and there may be nothing to demonstrate, but it is obvious that in many cases the new staple or variety will turn out well, and it will then be eagerly adopted by the neighbourhood. In a vast country like this, where demonstration farms maintained under the control of the Agricultural Department must always be far apart, the small plots attached to school gardens for demonstration purposes must surely be a most useful means of displaying new staples, varieties and methods, while the use of school gardens for these purposes will go a very long way to interest the people in the schools. The planting of suitable trees is another matter of which the villagers know little and they might learn much from a garden and nursery (*see* Plan) conducted under expert advice.

The *sixth* and *seventh objects* are closely connected. It is one of the principles of school gardens that except for the heavy work of ploughing where necessary, all the work of cultivation is undertaken by the boys themselves. Indian boys, like others, are interested in the mysterious processes of Nature. They enjoy seeing plants grow up as the result of the work of their hands, and they have naturally no prejudice against agriculture, but, if the atmosphere of a school is purely literary and the teachers, though originally villagers themselves, have been led, by the urban and purely literary atmosphere in which they have been trained, to despise manual

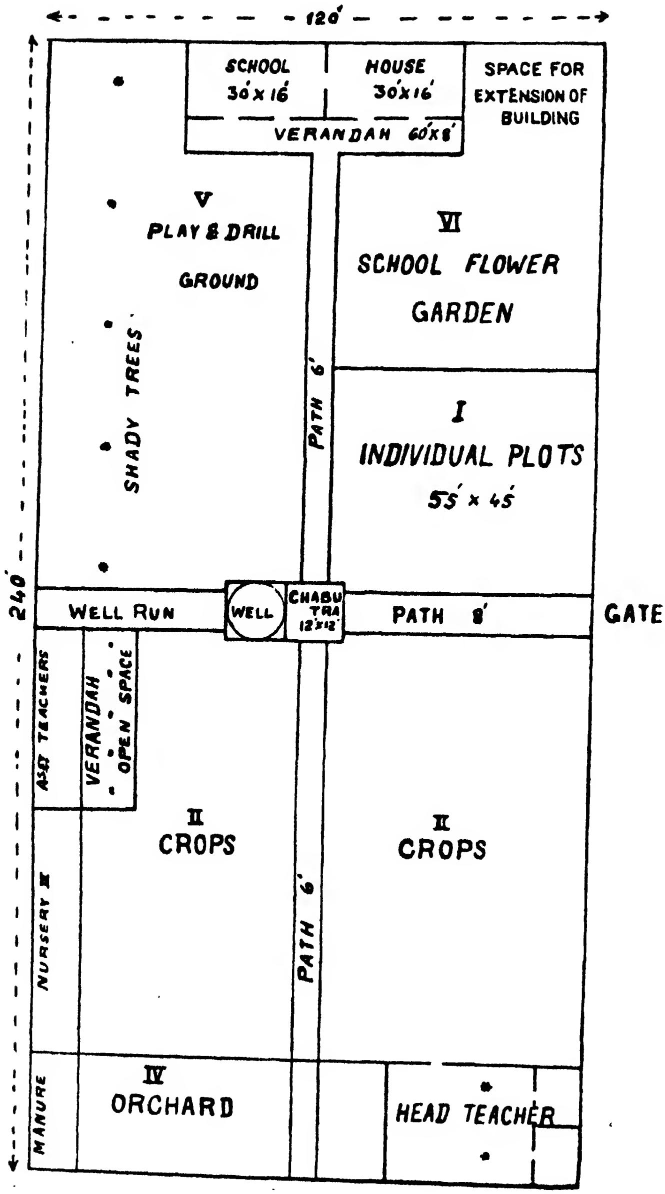
labour and depreciate agriculture, their ideas of gentility may be expected to infect their pupils, and an antidote is very necessary. In tending the gardens the boys also may learn how to co-operate with each other and, under the guidance of the teachers, to manage their own affairs, and may get their first lesson in the exercise of responsibility and in the duty of service to the community.

The *eighth object* is probably that which is most appreciated in western countries, though its utility is limited here by the paucity of teachers whose standard of training is sufficiently advanced to enable them to teach Nature study at all, or to make use of the garden in the teaching of other subjects; nor do the text-books at present in use give any assistance to the teacher in showing him how to utilize a school garden for the teaching of school subjects.

It was held at one time that object-lessons could take the place of Nature study, and that an inanimate object or even a picture of an animate object was a proper subject for study. Even now in Indian schools such lessons retain their place in the curriculum, and are defended on the ground that they cultivate a faculty of observation, but this theory has been put to the test and found wanting, and it is now almost universally acknowledged that the object-lesson should give place to Nature study which, in the words of a recent writer, "generates in the child a sympathetic interest in his natural surroundings—an interest which will ripen into the true spirit of scientific enquiry without losing the joyous impulsion of childhood." The recent Committee on Natural Science in England has adopted this view and recommended that Nature study should be taught in all rural elementary schools. At present in India Nature study as well as observation lessons are often included in the curriculum but cannot be generally taught as already stated. because the teachers have not been specially trained to teach them. It is generally regarded as non-essential in comparison with reading and writing, but since experience shows that most boys who leave the school at an early age after reading up to the Lower Primary standard, forget nearly all that they have learnt there, it would appear that Nature study, the effects of which are certainly lasting, would be of more educational value even than the three R's, and

PLAN OF SCHOOL GARDEN

(SCALE 40' = 1 INCH)



that special efforts should be made to train the teachers. Then a school garden would indeed be essential.

THE PLAN.

In order to form a school garden no great area of land is required. I annex a plan of one, the total area of which is 3,200 sq. yards, *i.e.*, two-thirds of an acre only.

The plan provides for a small school house, head teacher's quarters with enclosure, assistant teachers' bachelor quarters, and for a garden divided into six distinct portions as follows :—

First portion. A number of standard plots provided for each boy or pair of boys who want them and who are big enough to work them. These would be used chiefly for the growth of vegetables but partly also for flowers.

Second portion. A small field set apart for demonstration of new crops and improved strains of ordinary crops—wheat, rice, sugarcane, millet, groundnuts, etc.

Third portion. A nursery of young trees of different kinds to be planted out in the school compound or sold outside as required.

Fourth portion. A small orchard of fruit trees.

Fifth portion. A shady portion where school and drill can be held in the open air, sheds being erected if necessary, and where plants which do not mind shade can be grown.

Sixth portion. A small garden of flowers and flowering shrubs close up to the school.

THE LAY-OUT.

Having obtained the necessary land either round an existing school or having obtained a new site for the school, the first necessity is to build all round it a substantial brick wall 3 ft. high. This, at R. 1 per running foot, will cost some Rs. 720 and is no doubt an expensive item, but it is absolutely essential to have a wall, because no wire-fencing, ditch and bank, hedge or other enclosure will keep out goats, pigs, porcupines and other animals which do so much damage to a garden. A mud wall is as efficacious as a brick wall but requires constant repairs, and in the long run a solid brick wall is cheaper.

The land should then be measured and the different portions allotted on the ground.

The *first portion* (except possibly for the preliminary ploughing) will be worked entirely by the boys themselves, and they will choose the seed and take the whole produce. Vegetables and flowers will ordinarily be grown as chosen by the boys. They would be well advised first to try the common vegetables and flowers and then, if successful, those less well known in the locality. Among vegetables the following appear suitable :—Brinjals, sweet potatoes, radishes, carrots, beets, tomatoes, chillies, cauliflower, cow-peas, pumpkins, and cucumber. The District Board will supply seed of good varieties from time to time. This portion should be divided into individual plots for one student or pair of students. These will vary in size according to the number of boys and amount of land available, but an ordinary size for one plot is 12 by 3 ft., and there should be a path 1½ ft. wide between the plots.

The *second portion* should be worked so far as possible by the boys themselves. One of the teachers should keep an account of all the expenditure incurred, and after this has been paid off and sufficient seed has been retained for the succeeding year, the remainder should be distributed to the boys who assisted in the cultivation and irrigation. Seeds for the first year and for the varieties newly introduced should be supplied by the District Board without payment.

The *third portion*, a very small area, should, after the preliminary ploughing, be worked by the boys themselves in order that no expenditure be incurred. Zemindars and cultivators will be asked to supply seeds and plants of good kinds, and the District Board will also assist from time to time. The trees, as ready for planting out, will be planted in the school compound or sold or given away outside.

Fourth portion. This is intended for the demonstration of superior kinds of fruit trees to those ordinarily grown in the locality. They will be transplanted from the nursery as required.

Fifth portion. Some of the trees to be planted should be chosen for their shade-giving properties. There should be at

least two good shady trees—Bargad (*Ficus bengalensis*), Pipal (*Ficus religiosa*), Pakar (*Ficus Rumphii*) or tamarind. Other trees may be mango, Mohwa (*Bassia latifolia*), or Nim (*Melia*), all of which give fairly good shade.

Sixth portion. A garden close to the school. In the plan it is shown on one side of the central path. In it both flowers and flowering shrubs can be grown, and it should be worked by the boys themselves.

A well is of course a necessity unless canal irrigation is available. The cost varies so much in different localities that no estimate can be given.

Teachers' quarters. In order that the garden be properly tended, it is necessary that there should be some one living on the spot and this should preferably be the head teacher of the school. On other grounds too, it is desirable that he should be resident. The provision of decent family quarters adds to the comfort and self-respect of the teacher and makes him more contented with his lot and more interested in his school. Assistant teachers too generally live either, as they can, in some corner of the school house or at their homes some distance away; and in the latter case are frequently absent. It seems necessary that, unless they are actually residents of the village where the school is situated, they should live on the spot and only go home for week-ends. Accordingly for them also bachelor quarters are provided.

The head teacher's quarters, with enclosure, as in the plan, should cost about Rs. 100,0 and the assistant teachers' quarters about Rs. 430 each.

Conclusion.

Such is the kind of garden which I should like to see attached to all central schools. I recognize that the scheme is somewhat elaborate, that it requires the co-operation with the local authority of the educational, agricultural and horticultural authorities to bring it into effect, that it will further require, in order that the best use be made of the land, a special inspector or superintendent in each district. And more important than all, it will require the

whole-hearted support of one or more of the teachers in the school. A competent educationist indeed expressed to me his doubts, based on English experience, as to the possibility of doing anything useful through the agency of our present teachers, and feared that the only result of stimulating the laying out of gardens would usually be an untidy and neglected plot which would be an object-lesson of the worst type. He said that "it requires a teacher of exceptional qualities, physical and moral, to carry on a garden successfully." But circumstances are different in this country where school teachers are themselves villagers and brought up in an agricultural atmosphere. Experience in Allahabad, where portions of the scheme outlined above have been in force for several years past, show that many teachers are naturally keen on having a garden and only require guidance to make it a success, while the approval of inspecting officers, the competition between different schools for the best garden and an annual exhibition of produce provide sufficient stimulus for the large majority. And, indeed, if we are to wait till the perfect teacher arises before we take this first step towards introducing an agricultural atmosphere into our schools, we shall have to wait for generations.

DAIRY INDUSTRY AROUND COIMBATORE.

BY

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THERE are few places in the Madras Presidency which are more favourably situated than Coimbatore. It enjoys a very equable climate, neither too hot nor unpleasantly cold, with a steady western breeze blowing through a portion of the year. Geographically also it occupies a unique position. Situated in close proximity to the Nilgiri Hills, commanded by a railway, it affords facilities for any trade or industry that caters to the needs of the hills, unsurpassed by any other mofussil station in the south. It has a fairly large European population—certainly larger than in the ordinary headquarters of a district—due to the official as well as commercial importance that it commands.

Agriculturally too, Coimbatore is important. Owing to the even distribution of the annual rainfall which in itself is only moderate, the farmers have facilities which their fellows in other districts have not. Even in dry lands they raise crops very early, as the light soils nearer the hills are ready for cultivation earlier than black soils which are more remote. In light soils they often raise two crops—a cereal, generally Cumbu (*Pennisetum typhoideum*), and a pulse—while in the heavy soil, the season being later, only one crop is possible. In the latter type of soil the usual rotation is Cholam (*Sorghum*), cotton, and Bengal gram (*Cicer arietinum*). Besides these, there are garden and wet lands. The former are commanded by wells, while for the latter the sources of irrigational supplies are river channels or tanks. The supply of water in the wells in garden lands is fairly steady throughout. The water is lifted by

means of mhotes drawn by bullocks which walk up and down a steep ramp. Three crops, two cereals, generally Cholam and Ragi (*Eleusine coracana*), and an industrial crop like tobacco, are raised. These are very intensively cultivated with heavy application of cattle manure.

In wet lands there is only one crop—paddy—though sugarcane is also cultivated in small patches. Green leaves for paddy and sheep penning for sugarcane are the recognized manures. It is obvious that whether it be for cultivation, irrigation, or manure, the garden land ryot is in continual demand for cattle.

With regard to cattle, Coimbatore is exceptionally privileged. Situated in the Kangayam country which is famous for its remarkably good breed of cattle, Coimbatore enjoys the enviable position of possessing one of the finest types of working cattle, both for mhote and draught purposes. It also draws on Kollegal grazing tracts for a large proportion of its working cattle. The cows of this breed (Plate IV, fig. 1), however, contrary to one's expectations, are but poor milkers and are maintained more for breeding purposes than for their performances at the pail.

The grazing grounds for cattle in the neighbourhood are not abundant. These are, however, available a few miles distant near the hills, where the hill tribes—Irulars—graze cattle for a nominal fee during the off season. Stall-feeding is a necessity, although there is a kind of grazing obtainable, throughout the year, on the tank bunds and roadsides, which carries with it all the evils which communal grazing entails. The bulky food consists of any available green fodder like *cholam* and *ragi* straw or green grass. For concentrated food, cotton seed is given twice daily along with some *cholam* water obtained by soaking the grains overnight. Cakes and bran are little known. When dry, the animals are put on a dry ration.

Cow keeping being unprofitable, the buffalo (Plate IV, fig. 2) is the mainstay of the dairy industry. Being an animal which thrives on rather coarse food such as that rejected by other live-stock, and one which can without prejudice be put to work in wet lands, when not milking, the milch buffalo is sought after especially on account

Fig. 1. A Kangayam cow.

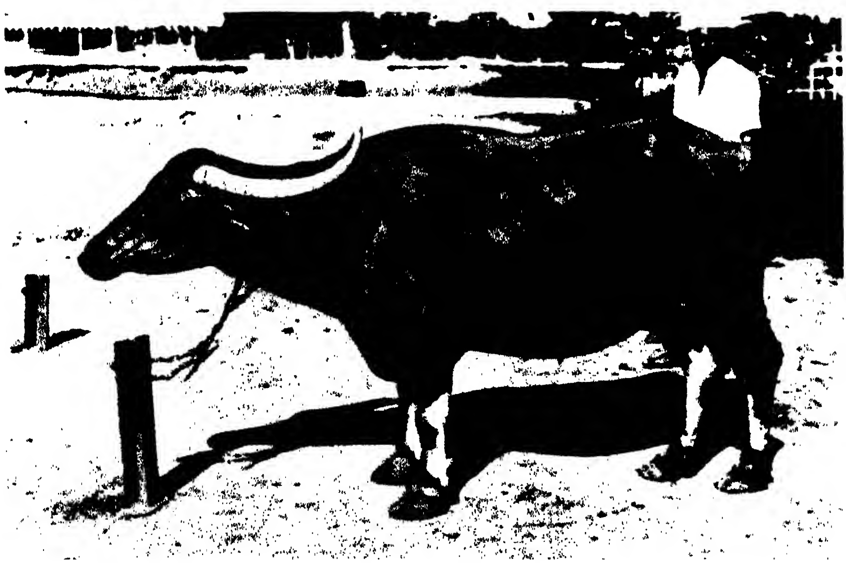


Fig. 2. A Coimbatore buffalo.

of the milk which is better both in quality and quantity than the cow's. Popular sentiment, however, among the educated classes is against buffalo milk owing to the belief that it is prejudicial to the health of young children. The average buffalo justifies its existence by yielding 10 to 12 lb. of milk per day, and such an animal is worth about Rs. 75 at the present prices. The upkeep of such an animal per day is about 5 annas, while the milk it produces is worth annas 10 to 12 at 1 anna per pound. Cheaper animals can, of course, be had which yield correspondingly reduced profits. Their maintenance through the dry period presents no great difficulty. Bad milkers are disposed of, as soon as they calve, even at a small loss.

The dairy industry is also carried on as a subsidiary source of income by cultivators who are either tenant farmers or peasant proprietors. These are usually Tamils of whom Goundans, Vellālas, and Konaris claim particular mention. Besides these, there are two sections of the Telugus, namely, Gollas and Kammas, who immigrated into these parts from the north and are reckoned to be as good cultivators as their Tamil neighbours.

Among these those who possess garden lands are fairly well-to-do. They include in their herd a few milch buffalos which supply milk, curds, and *ghee* (clarified butter). The ryot does not keep more buffalos than he can find a use for, but a landlord owning 10 acres would probably have two or three buffalos in milk, and the surplus milk generally goes to meet the needs of the town. The peasant proprietor, however, contents himself with only one, rarely two. The usual custom is to have two animals, one of which is always in milk.

Of the castes mentioned above, Konaris are professional traders in curds and *ghee*. Their condition is not so prosperous as that of Goundans and they prefer cash transactions to monthly settlements. The trade is entirely in the hands of the womenfolk. It keeps a woman fairly independent of her husband for her daily necessaries, besides saving her from earning her livelihood as a day labourer. Though it means a good part of the day spent in the town, she prefers to carry her headload inasmuch as she gets her

business done and contributes her share to the village gossip which she loves so much.

Let us consider the profits of this *ghee* trade. From a buffalo yielding 10 lb. of milk daily, ½ lb. of *ghee* is obtained, according to actual tests. At the present prices this is worth only 5 annas. This is therefore too low a figure to derive any profits from. The *ghee* is, therefore, heavily adulterated so that it fetches nearly the value of 10 lb. of milk. Besides *ghee*, she obtains curds which are diluted to make up 15 to 20 lb. which will sell at about R. 0-2-6. This then is probably the profit in the transaction. At the present rates pure *ghee* manufacture is certain to mean loss, and the only course left to the traders is to adulterate it and thus keep the price as low as possible.

The existence of the College Dairy in this vicinity has created a market for some portion of the surplus milk of the locality. It obtains from the surrounding villages milk totalling up to about 400 lb. daily. This milk is put through the separator, and the cream is pasteurized and converted into butter, which finds a ready sale not only in Coimbatore but in different parts of the Presidency. The average monthly sales of butter alone come to about 700 lb., besides disposing of rich fresh milk obtained from a good herd of cross-bred and country animals (Plate V, fig. 1). A good portion of the separated milk used to be sold at 4 pies a lb., but recently the price was raised to 6 pies and even at this rate there seems to be a good demand. The College Dairy has thus demonstrated an industry to the ryots, to the peasant proprietor in particular, in which class may be included the day labourer and the Government peon whose meagre income is insufficient to support his family in comfort. Even these realize that there is profit in a milch buffalo, and in fact one of the arguments once brought forward by a peon in defence of a second wife was that a buffalo would maintain her!

Yet another industry has sprung up in the last decade in the surrounding tract, which is certainly not indigenous and which is not unworthy of our consideration, if not merely for its intrinsic merit, at least for its popularity among the village folk.

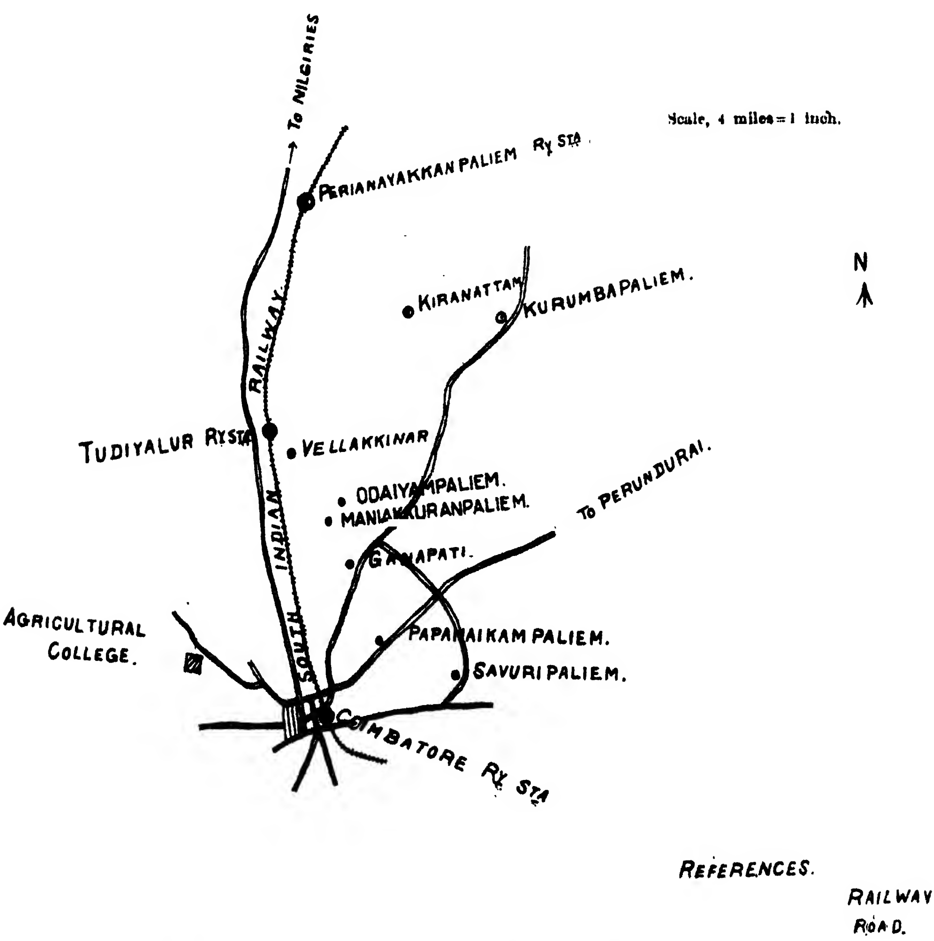
Reference has already been made to the nearness of Coimbatore to the Nilgiris. These hills, besides being the summer

Fig 1. The Coimbatore College Dairy Herd.

Fig. 2. A creamery man with a separator, and brass vessels. Note the method of packing the tin containing cream ready for transport to the hills.

headquarters of the Madras Government, attract in summer numerous visitors. Besides, the fertile soils of these hills, combined with the climatic advantages, offer exceptional facilities for the existence of a fairly permanent population, which, being mostly European, has created a demand for dairy products in the shape of milk and butter. To meet this demand a special industry has been organized.

A little over 15 years ago there came to the hills a young Parsee on business. With the foresight and business acumen which seem to be inherent in his race, the Parsee grasped the situation and set himself to solve it. There was a large European population in



Map showing villages in Coimbatore taluk where creameries exist.

need of genuine dairy products. The local supplies were barely sufficient to meet the demands for milk, but where was the butter to come from? He started with the hill buffalos, but the demand soon outweighed the supply. Then he visited many villages in the neighbourhood of Coimbatore and established a sub-station within a couple of miles of Coimbatore and arranged for an agent who purchased milk in the neighbourhood, separated it, and sent the cream by rail to Wellington, while disposing of the separated milk locally as best as he could. He could hardly touch 50 lb. at that time. The Parsee made friends with villagers, and even went so far as to obtain for them cream separators free, and appointed agents who supplied him with cream. The result has been that to-day there is a chain of villages dotted all along the railway line running north to the hills from Coimbatore (*vide* Map), in which there is a well organized system of creameries, run for all intents and purposes on business lines, and at the present moment without exaggeration it could safely be estimated that about 3,000 lb. of milk are being dealt with daily in the season at these creameries in about nine villages, excluding the town of Coimbatore itself.

The management of the creameries may now be considered. Although the supply of milk is in the hands of the cultivating classes, the management of the creamery itself is not with them. The creamery man is of diverse callings. He may be a petty building contractor, or a discharged cook of a wealthy landlord, or again a poverty-stricken weaver thrown out of his trade. Sometimes he is a Christian originally of an enterprising caste, or a leisured village postmaster, but hardly ever a genuine cultivator. The farmers view this enterprise with suspicion, probably because creameries are speculative concerns and naturally the ryot looks well before he leaps. They, however, admit that there is money in it if properly run. The creamery draws its supplies of milk from the cultivating classes of the villages in the neighbourhood. The creamery itself is a part of the dwelling house often rented for the purpose. It is invariably an ill-ventilated and insanitary corner of a main room in which children play and women cook. Or sometimes if the owner is desirous of having more ventilation, he makes use of the verandah

where pedestrians and flies congregate. To such a place the milk is brought by the village women, frequently in open copper vessels, never earlier than 10 o'clock, and the creamery is at its busiest between that hour and noon. The milk is tested by the lactometer in each case, not filtered but poured into large copper vessels after the quantity is measured. The woman gets her book filled in, and while doing so the creamery man makes a large allowance for any suspected sample. He then records in his register the quantity purchased. Any reduction in milk is generally echoed in a protest, but the woman has the cure for it in her own hands.

To encourage customers to bring more genuine samples, certain creameries adopt different prices for milk, but it is not likely to work very satisfactorily as they rely entirely on the lactometer which at best is only a rough and ready test.

Fat analyses of samples of milk taken at random from some creameries are tabulated below, and give an idea of the standard of quality maintained in them. The milk is invariably buffalo's but sometimes there is an admixture of cow's.

Village	No. 1	No. 2	No. 3	No. 4	No. 5	Average*
	%	%	%	%	%	%
Ganapati	6·5	4·5	3·8	4·2	4·8	
Kiranattam	5·3	5·2	...	...	...	5·4
Savuripaliem	5·4	5·0	5·5	5·4	4·9	...
Papanaikampaliem	3·3	2·1	4·6	3·9	5·5	4·6
Perianayakkanpaliem	7·0	6·6	8·2	8·5	5·2	6·6
Vellakkinar	6·7	7·1	4·8	9·0	...	7·7

* The average sample was taken from a quantity of milk varying from 100 to 200 lb.

Taken all round, except in Papanaikampaliem where the milk is exceptionally bad, the samples are of fairly good quality, and especially so in Perianayakkanpaliem and Vellakkinar which are far from the evil urban influences. The creamery men pay at 16 lb. per rupee in the last named places, while in the others 20 lb. per rupee is the rate.

The equipment of the creamery cannot be simpler. It consists of a separator usually secondhand, the size depending upon the quantity dealt with. The separator is of various makes, but the commonest is Alfa Laval. Diabolo and Heinrich Lang Mannheim are also found. A lactometer (metal or glass), two large brass

vessels, milk measuring cans, and a number of old kerosene tins make up the rest of the equipment (Plate V, fig. 2).

The following is a rough estimate of a creamery as equipped above :—

	Rs.	as.	p.
1 Separator (secondhand)	250	0	0
1 Lactometer (metal)	10	0	0
2 Brass vessels	30	0	0
2 Measuring vessels	2	0	0
12 Kerosene tins	6	0	0
	298	0	0 or

roughly Rs. 300.

Let us consider the returns of one who has no room rent to pay. It is estimated that 300 lb. of milk produce 1 tin of cream weighing about 36 lb. His expenditure is as follows :—

	Rs.	as.	p.
Cost of 300 lb. milk @ 20 lb. per rupee	15	0	0
Cooly from creamery to railway station	0	1	0
Railway freight on one tin from creamery to Wellington ...	0	7	0
One girl to help in washing up	0	2	0
Depreciation on separator, etc., per day	0	2	0
	15	12	0

The dairyman pays the creamery man at 11 annas for every pound of butter manufactured, and the usual proportion of butter to cream is between 66 and 70 per cent. ; so that from 1 tin of cream about 24 lb. of butter is obtained which is valued at Rs. 16-8-0, and this means there is a gain of only a few annas by the transaction. Where then is the attraction for this industry ? The townsman has of late found separated milk to be a good substitute for milk. This finds a ready sale in coffee and sweetmeat shops, in Hindu hotels, and in fact even in well-to-do Indian homes. If the creamery is at all get-at-able, there is an excellent sale for separated milk, so that, even at a conservative estimate of 3 pies per lb., there is a net gain of about Rs. 3, provided the whole of separated milk is disposed of. This, however, is not the case. The creameries are not all situated near a large town like Coimbatore. Even those which are more favourably situated, are sometimes unable to dispose of it owing perhaps to a dislocation of trade due to epidemics like plague. Wherever conditions are less favourable, the separated

milk is converted into curds and sent either to Coimbatore or railed to Palghat where demand exists for curds. If this is not possible, then the separated milk has to be thrown away. These all mean reduction in profits, so that if Rs. 3 per day is obtained under exceptional conditions even a rupee under less favourable circumstances is not too little to be ignored. It is clear, therefore, that the larger the quantity of separated milk sold, the greater the profits of the creamery.

It may be quite a pertinent question to ask if this enterprise has been successful throughout. As in every other enterprise, this has not been without its pitfalls and some have profited from the failure of others. It cannot be said that every one succeeds. The writer's attention was drawn to a particular instance where a creamery man believing the words of a wily Mahomedan agent of a dairy at Madras, kept sending on cream until his liabilities went as high as Rs. 1,500; eventually, assisted by his old master, the creamery man threatened to go to law. When settlement was made, he was the loser to the extent of about Rs. 800 in the concern.

The conditions suitable for a successful creamery are: firstly, there should be facilities for the purchase of good milk; secondly, the creamery should be able to dispose of the major portion of the separated milk; thirdly, the creamery man must have business instincts; and, fourthly, there must be a steady demand for the cream. The small initial outlay, the little trouble attached to the business, and the quick returns tempt a non-agriculturist to launch on this speculative undertaking. Granting that conditions mentioned above are available, it is undeniable that there is money in this business.

Should we trace the destination of the cream we should find it still more interesting. One would notice while travelling in the morning train to the hills, a number of kerosene tins packed in plantain sheaths arriving at Coonoor and Wellington. They contain cream consigned to dairies. These are unostentatious in appearance. One which did the greatest business had for its activities the outhouses of a modest villa situated in an unfashionable locality of the town. Although the conditions were filthy to the extreme and the methods of manipulation totally crude and unscientific, it was

amazing how fine a product was obtained with the cream which reached its destination in varying degrees of fermentation. The knowledge of technique of the dairyman was nil, his apparatus was meagre, and yet he was daily manufacturing 100–120 lb. of butter at the time of inspection and which he disposed of without any difficulty in the neighbouring hill stations. Thanks to the climatic facilities, the texture of the butter was good, although there was a good deal of room for improvement in the matter of cleanliness. Samples of butter obtained from three dairies are given below which speak for themselves.

Particulars	Government Military Dairy, Wellington	The Nilgiri Dairy, Wellington	Coonoor Dairy	REMARKS
Moisture	11·72	14·16	7·81*	* Sent packed in tissue paper which absorbed some of the original moisture.
Fat	86·60	84·06	90·43	
§Solids, not fat... ...	1·60	1·61	1·16	
Total ...	99·92	99·83	99·40	
§Containing casein ...	0·59	0·49	0·50	
Reichert Meissl number	29·6†	21·7†	22·80	† Mean of two determinations. No. 1 was a very soft butter.
Refractive Index corrected to 40°·C.	1·4549	1·4554	1·4551	

The manufactured article is placed in different sizes on dishes covered over with cloth and sent round to customers who gladly purchase it at R. 1 per lb. The recurring expenditure is small. The water is cold enough to render the use of ice unnecessary. One man is employed in churning and another for selling. Even allowing that he pays 3 annas a pound for initial capital, recurring expenditure, and establishment, the dairyman makes in the busy season a clear profit of 2 annas on every pound of butter manufactured, but during the off season he would necessarily manufacture less. This industry demonstrates clearly what an extensive demand there is for dairy products around Coimbatore, and it does not need much imagination to peer through this vista into the future of the dairy industry in India managed with scientific and business knowledge.

THE SEASONAL FACTOR IN CROP STATISTICS: A METHOD OF CORRECTING FOR THE INHERENT PESSIMISM OF THE FARMER.

BY

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STATISTICS of all sorts are usually held to be a very dry subject, yet properly considered they may be full of human interest—especially to the compiler—from the side-lights they throw on the psychology of those who supply the detailed information on which the statistics are built up. The war has shown us how valuable would be really accurate statistics of the production of the several main crops in India. These figures depend on three factors—area, normal outturn per acre, and the seasonal factor—which, when multiplied together, should give the gross outturn.

So far as the Madras Presidency is concerned, the figures of area available in arrears at the end of a revenue year are extremely reliable. The same cannot be said for the figures supplied in advance to the Director of Agriculture for purposes of crop forecasts, but the modification of these so as to approximate more closely to the eventual final figures affords that harassed officer an opportunity for the exercise of ingenuity in which a knowledge of the state of the season is not so important as an appreciation of the psychology of the village accountant and the taluk clerk, and an estimate of the state of departmental discipline of particular districts. A taluk was found recently where no village accountant kept any accounts and where all figures were invented at the close of the year, or so it seemed—but that is another story, and for the credit of Madras an exception.

The figures of normal yield per acre are, in Madras, based on a large number of crop cuttings, mostly carried out by Settlement Officers; but it must be admitted that the figures in most cases are only a rough approximation to the truth. The writer believes that the only way to improve them is to abandon the method of averaging a limited number of crop cuttings—which amounts to working from the particular to the general—and to reverse the process and work from the general to the particular. If the total yield of a particular tract can be ascertained, then this total divided by the area under the crop gives the average crop per acre for that year. Do this for a series of years, and we obtain a most accurate figure of average yield per acre. The only crop for which this method has been tried in Madras is cotton. Fairly complete figures of the cotton crops are being obtained from presses and mills so that the average crop per acre for each important tract is now known accurately for two years at least. Cotton is the easiest crop to which to apply this method, because the local consumption for hand-spinning is so small as to be negligible. In the case of food grains, on the other hand, the local consumption is the important factor in estimating the total yield, but the writer believes that it would not be impossible to form a fairly accurate estimate of the total yield of a staple food grain in a particular tract by a consideration of the average annual consumption per head of population together with the statistics of export and import by rail and sea.

Thirdly, there is the seasonal factor. Any estimate of the total crop based on statistics of exports and mill and factory consumption, must of necessity be made in arrears, after the crop has been sold and moved. Such statistics can be used to tell us what the average crop per acre of the previous year *has been*, as explained above, but they cannot of themselves tell us what the current crop *is going* to yield per acre, and it is this information which is required of us by merchants, railway companies, and the public generally. To obtain this we must form an estimate of how the current crop differs from our normal average standard. In Madras such an estimate is framed by each village accountant. The area under

each of the crops in his village is classified by him under one of five heads, *i.e.*, 16 to 13 as., 12 as., 11 to 8 as., 7 to 4 as., 3 to 0 as. The area under each of these heads is totalled for the taluk and the district and a weighted average struck, and this is then reduced to a percentage, taking 12 as. as equal to 100 per cent. Until last year the figures thus obtained were published by the Board of Revenue, in the annual Season and Crop Report, as the percentage of a normal crop obtained in each district. Now the village accountant, like most farmers, is a pessimist and thinks poorly of most crops. He is told that 12 as. represents a normal crop, but to him a normal crop is the crop he would like to see, but rarely does see. Consequently the final integration of the estimates of the large number of village accountants always works out at very much below 100 per cent.—it is usually nearer 75 per cent. This is only what is to be expected. A normal average crop is not easy to envisage. It is difficult to bear in mind that the average crop over a large tract would have its fair share of crop troubles of all kinds. If shown a really average crop most of us would see sufficient faults in it to put it down as much below 100 per cent. The same thing will be noticed in the American cotton forecasts where the "condition figure" of the crop is always below 100 per cent. This fact is frankly recognized by the American Department of Agriculture and explained by stating that the normal crop which corresponds to their 100 per cent. is admittedly a crop without any serious defects and therefore considerably above an average crop.

As stated at the beginning of this paper, the total yield of a crop is estimated by the following formula :—

Total yield = Area × average yield per acre × seasonal factor.

Now to obtain an accurate result the second and third factors must refer to the same standard. If the second factor referred to a normal crop which was considerably above the average, then it would be right to take the yield of this "normal" crop as the 100 per cent. standard for the seasonal factor, and not the yield of an average crop. But even the method of averaging crop cuttings made on good, bad and indifferent crops gives something much nearer the *average* crop than a fictitious "normal" crop, while

the method of calculating this second factor by dividing the average total yield by the average area, as recommended above, gives us emphatically a real *average* crop and not any imaginary "normal."

It therefore follows that our third factor should refer to a really average crop and not to the good crop without defects to which the village accountant now instinctively refers it. A method of effecting this has been suggested by the writer and has been adopted in Madras since last year. The question is, "What is an average crop?" The answer, which seems obvious when stated, but which does not appear to have been so stated before, is "the crop which the village accountant reports over a series of years." Take, for instance, a district where the integration of the estimates of all the village accountants has yielded the following percentages of a normal crop of, say, rice :—

	Years.										Average for 10 years
	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	
Percentage of "normal" crop ...	68	79	72	85	81	74	72	83	67	75	75·6

Now, assuming that 10 years is a long enough period to take to eliminate seasonal fluctuations, it is perfectly obvious that an average crop in this case is the crop which the village accountant marks as 75·6 per cent. on his scale. (We may also deduce that the accountant's mental standard of a "normal" crop is one which is $\frac{24 \cdot 4}{75 \cdot 6} \times 100 = 32 \cdot 3$ per cent. *above* the average.) Now suppose that the seasonal factor for the year 1916 works out, on the same basis, as 83 per cent. We then know that this season's crop, so far as we may judge from the village accountants' estimates, is *better* than the average, and can be represented by $\frac{83 \times 100}{75 \cdot 6} = 110$ per cent., if the average crop is represented by 100 per cent.

The process described above consists essentially in adjusting the middle point of the village accountant's scale of estimating so as to make it coincide with 100 per cent. Anything above 100 per cent. then represents a crop above the average of the past

10 years, and *vice versâ*. Considering that the figures with which we are dealing represent the sum of a very large number of small observations, we can place considerable reliance on them as being correlated with real differences in the crops of the different seasons. The first thing necessary to enable us to make good use of these figures is to reduce them to a fixed standard scale, and it is claimed that this has been done by the method explained above. It is probably enough to take the average of 10 years as our standard, but if not, it is just as easy to take 20 years or even longer.*

It is also probable that the scale could, with advantage, be broadened out, either symmetrically or asymmetrically. It is assumed at present that a 16 as. crop is double, and a 4 as. crop is half, of an 8 as. crop, whereas the real ratio may be different. But to evolve a formula for this correction would imply a detailed study of the variation in yield of crops with season and the correlation of this variation with the village accountant's estimates, a piece of research which has not been taken up.

It may be mentioned that the correcting factor, *i.e.*, 100/75·6 in the case taken above, should be worked out separately for each crop, and for each district. A detailed study of the figures shows that great variations exist between different crops and districts in Madras. For instance, sugarcane is always estimated at somewhere near 100 per cent. presumably because it does in fact vary very little in yield under the conditions of high cultivation and continuous irrigation. And it is evident that the mental image of a normal crop formed by the village accountant is influenced by the gross yield of his village as compared with that of adjoining tracts. For instance, the rice lands of the Coimbatore District are mainly concentrated in very fertile strips along the banks of the Cauvery and its tributaries, while the few remaining rice lands in the district are irrigated from rain-fed tanks and are comparatively inferior. Consequently the average estimate (uncorrected) for rice in Coimbatore usually comes out at nearly 100 per cent., the good estimates made for the fertile strips outweighing the low estimates

* It has now been decided to take all years for which figures are available.

made for the small area of poorer lands with which they are mentally compared.

This method of correcting for the natural pessimism of the crop estimator can of course be applied to the estimates made by any agency, even to cases where the seasonal factor is estimated for whole districts by one officer. But when the number of estimates with which we are dealing becomes few, the effects of changes in the estimating staff, or even in the point of view of the individual officer, become more marked, until a point is reached at which it is not safe to take the average of past years' estimates as a standard. We lose, in fact, the smoothing-out effect of large numbers, which, in the case of the estimates framed by village accountants, gives us a firm basis on which to work.

THE NEED AND OBJECTS OF A SOIL SURVEY IN THE PUNJAB.

BY

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The object of this paper is to draw attention to the need in India of systematic soil surveys. The paper was originally read before the Lahore meeting of the Indian Science Congress, but has since been somewhat altered and extended.

The elaborately organized work of the American Bureau of Soils is an example of what a systematic survey can do for the agriculture of a country. The productive capacity of the soil and its peculiarities must always be the first consideration in applying scientific methods to agricultural practice, and it is only with such knowledge at its disposal that the Agricultural Department can hope, with confidence, to educate the cultivator in the best methods of working, and the most suitable crops for his conditions. Besides the direct profit to the cultivator, for which the work of the American Bureau of Soils has been responsible, in suggesting new and more profitable crops in localities where they had not previously been introduced, and in explaining and indicating the remedies available for the treatment of infertile soils, the accumulated results of years provide most valuable data for the soil scientist all over the world.

Work on more limited districts has been conducted on the lines laid down in the classical work of Hall and Russell in many of the counties of England and Wales and has had far-reaching results.

With the exception of limited areas in India, no systematic survey of soils has been possible in the short time the Agricultural Department has been in existence. Confronted with the enormous field of work which is open to the investigator of Indian agricultural problems it is not surprising that amongst much that has been done there still remains the formidable task of standardizing the results. Besides the submergence of this necessary work by the mere press of other and obvious problems, two tendencies must be recognized as deterrent. The first is the tendency to investigate the abnormal rather than the normal; the second is the practice of referring analytical results obtained in India to the standard types isolated by workers in other countries, England and America. In the absence of a thorough knowledge of *normal* Indian soils and their agricultural properties, this is the only course which can be adopted at present. But the necessity of detailed study of our own soils must not be lost sight of. When the influence of the various factors which so profoundly modify the properties of soils, which from their chemical and mechanical composition seem similar, has been thoroughly elucidated, the practice will be admissible and profitable, but not till then.

Besides the direct agricultural value of a thorough knowledge of the typical soils of a district, a soil survey should prove of use to the Revenue Department, especially in connection with settlement.

A more direct application is to be found in uncolonized tracts which are capable of irrigation. A trained staff, with sufficient systematized experience behind it of soils in similar tracts, should prove of great value, firstly, in determining the prospective value of the land which it is proposed to bring under cultivation; secondly, in influencing the design of the canal system; and, thirdly, to the Colonization Officer when the district comes to be settled. My point can best be illustrated by reference to actual examples.

The Lower Bari Doab Canal was designed to irrigate 871,000 acres, and was expected to derive Rs. 38,51,109 in revenue. Five main types of soil are recognized: *Bara, Bari, Maira, Kalrathi,* and *Dhaya.* Bara soil is characterized by intense hardness. It is quite

desert, and rings when struck as though it were cast iron. The mirage is a characteristic feature of the landscape where this soil is present. It is usually low lying, and water stands on it for a long time.

Bari soil is similar to Bara but not quite so bad. Kalrathi is a rather different type of soil characterized by a hard crust which contains considerable amounts of alkaline salts. The crust is well defined and can be cracked off, the thickness varying from ½ to 4 inches.

Maira is a loose sandy soil, and Dhaya is very uneven land of hillocks and ravines. The area covered by these types is as follows :

	Acres
Bara	104,163
Bari	75,093
Kalrathi	78,583
Maira	49,706
Total	307,545

Of this the Revenue Department consider 121,091 acres as problematically culturable, while the residuum, 186,454 acres, is classed as unculturable. Thus 23 per cent. of the total commanded area is bad land.

The annual land revenue and water rate (gross) on this area must be put at Rs. 12,00,000. If we take it at Rs. 10,00,000 net it is over one quarter of the total net revenue (Rs. 38,51,109) expected from the Lower Bari Doab Canal and over one-eighth of the total net income expected from the Triple Canal Project as a whole.

Unfortunately, the survey was made after the canal was under construction. Now the canal is there, all that remains, in order to save the project from financial failure, is for the Agricultural Department to see what can be done with the 186,000 acres "unculturable soil" and 121,000 acres "problematically culturable."

The process of canal colonization is seen in its early stages in the case of the Sind Sagar Project. Between the Indus and the Chenab we have the districts of Mianwali and Muzaffargarh, which are mainly arid regions with scattered and small tracts where well irrigation is practised. The scheme is to draw off water from the

Indus at Mari for the irrigation of this tract. The rough project is being drawn up on results of previous Government of India surveys. The Survey Department will now make a detailed survey before construction commences. Some analyses of soils of this district have been made by Hooper, which are reprinted in Table I. Only chemical analysis is available and the samples are too scattered to obtain any very clear idea of the nature of this soil. I understand, from officers who have toured in this region, that a large proportion of the soils are sandy, and this fact, apart from their agricultural value, should be taken into account, in designing the canal, by the Irrigation Department. An examination of the permeability of the subsoils would enable a prediction of the possibility of dangerous seepage to be made, and would thus allow of the adoption of preventive measures, such as water-proofing, in the design. The importance of taking seepage into account in the design is fully realized by the Irrigation Department, whose experience in other colonies has shown the difficulty of attacking this evil once the canal is built.

The supply of water in the five rivers is not inexhaustible, and there must be competition between the large tracts which are yet open to irrigation, for the wealth they bring. The probable value of the land, when irrigated, must be known when deciding conflicting claims, and this knowledge can be obtained only by a systematic soil survey.

The first step in systematizing our knowledge of soils is, of course, to devise some method of classification. In the Punjab we are dealing for the most part with a vast tract of alluvial deposit, and consequently a geological basis of classification, as has been used in other countries, is impossible on account of the lack of differentiation. This does not mean that the diversity of structure and agricultural properties of the soils met with will be less marked.

The American Bureau of Soils bases its primary classification on the origin of the soils; this first classification results in the establishment of large soil "provinces." The next subdivision is effected by considerations of colour, subsoil conditions, etc., and enables a classification into "series" to be made. The "series"

TABLE I.

	I. Surface of Tha			II. Hard soil of the Hills				III. Blown sand				IV. Root sand	
	1	6	20	5A	34	50	51	9B	32	57	75	14	27·31
Iron oxide	2·80	3·20	1·60	1·80	4·60	2·60	2·00	1·40	2·60	1·60	1·80	2·80	2·00
Alumina	2·60	2·7	3·15	1·40	6·30	3·57	3·02	1·15	2·40	1·51	1·31	1·75	2·45
Potash	0·21	0·39	0·06	0·06	0·45	0·25	0·14	0·11	0·10	0·06	0·05	0·12	0·10
Phosphoric acid	0·09	0·24	0·13	0·11	0·20	0·21	0·22	0·23	0·18	0·09	0·07	0·23	0·15
Carbonic acid	4·65	3·40	3·21	2·75	7·36	5·79	2·61	1·50	3·91	1·75	1·18	2·00	2·26
Insoluble silicates	83·36	81·18	86·22	90·04	64·46	80·42	86·00	92·18	85·28	92·21	93·00	89·02	88·61

are then divided up into "types" according to the mechanical constitution of the soils composing them.

The value of mechanical analysis in the examination of soils is too universally recognized to need much comment. In the Punjab, this must serve as our main basis of classification. At Lyallpur a centrifugal method of separating clay and silt fractions, as introduced by the American Bureau of Soils, has been adopted and found to give satisfactory results with a great economy of time. A specially constructed shaking-machine enables twenty-four samples to be prepared for analysis at one time.

A simple method of classifying soils, based on their mechanical analysis, is required when dealing with a large number of specimens. The series of figures by which the result of analysis is usually expressed is not easily comprehended, or amenable to a system of cataloguing. A graphical method has many advantages, since the position of a soil, with respect to standard types, can be seen at a glance. Moreover, it is possible to indicate by the size of the circle representing a soil the limits within which variation is allowable for a particular soil. The method which I have adopted provisionally consists in plotting on a triangular diagram the percentages of silt, sand, and clay. This has several advantages over the method adopted by the American Bureau of Soils for the purpose, since the percentage of the third component can be read off the diagram at a glance. The diagram used by them is reproduced as Diagram I. It must be remembered that the sizes of the fractions corresponding with silt, sand, and clay, differ in the two cases, as shown in Table II below. This accounts for the fact that soils appear to be classed

TABLE II.

Limits of diameters in millimeters	Sand		Silt		Clay	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
American ...	2·0	0·05	0·05	0·005	0·005	...
English ...	1·0	0·04	0·04	0·002	0·002	...

as clays in one diagram which may contain 5 per cent. less of this constituent than the other. Thus in American analyses all particles of

Diagram I.

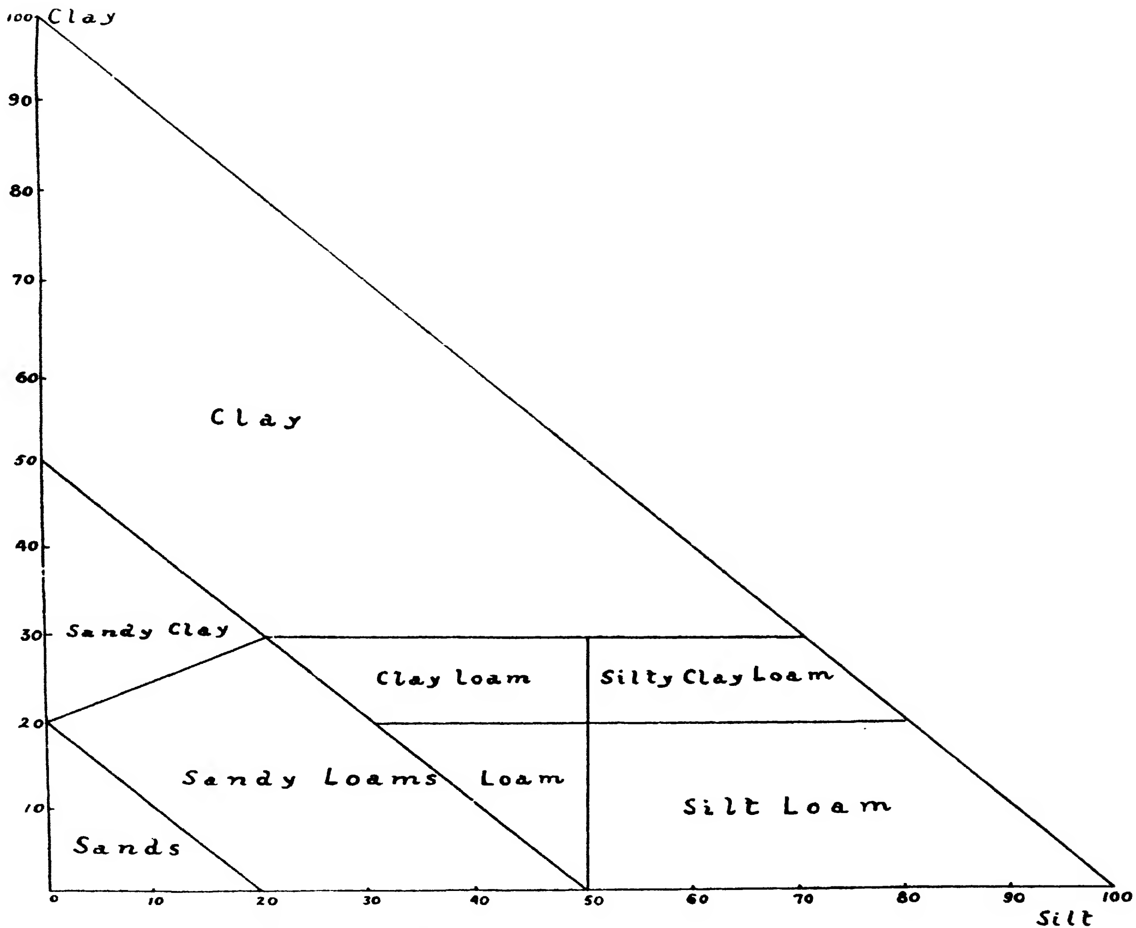
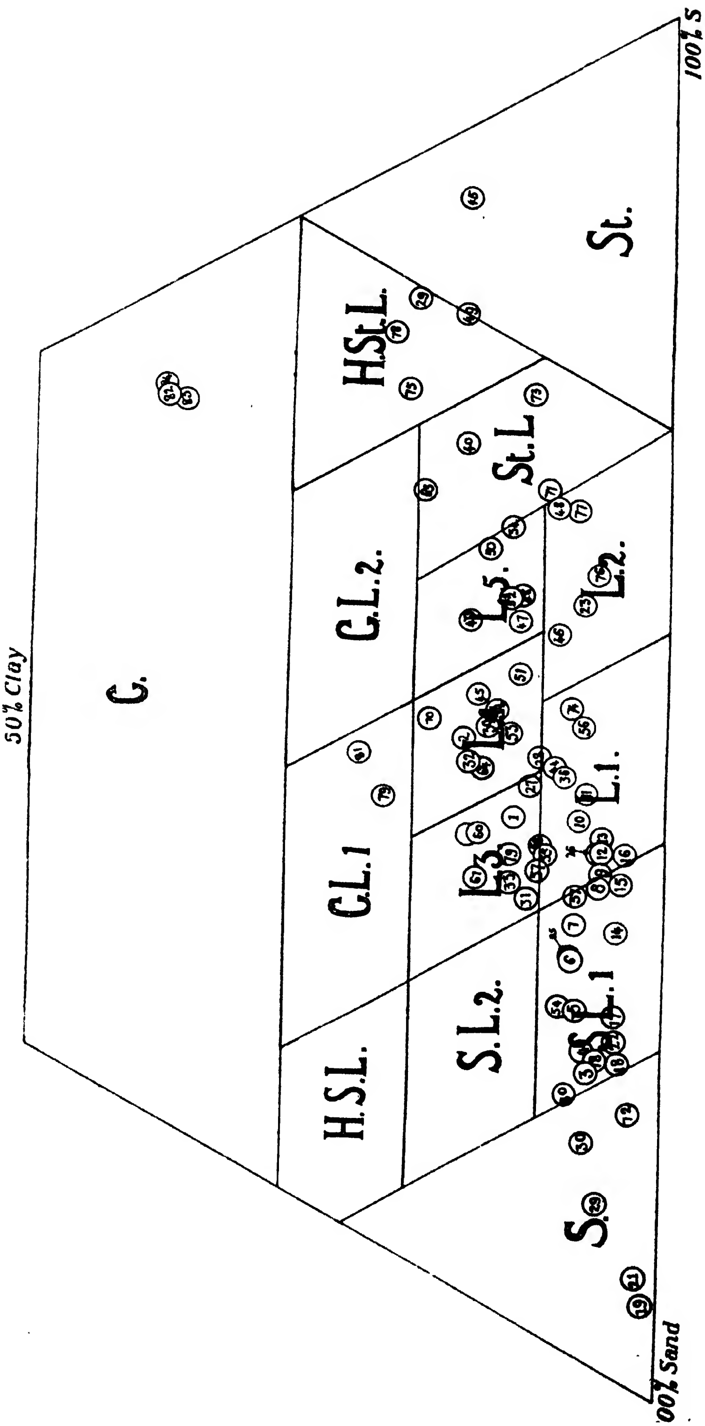


Diagram showing classification of soil material according to mechanical analysis.

Diagram II.



less diameter than 0·005 mm. are considered as clay, while in English analyses 0·002 mm. has been fixed as the maximum limit. The fourteen compartments into which the diagram has been divided, represent mechanical constitutions within the following limits.

TABLE III.

Description	Percentage		
	Sand (+0·04 mm.)	Silt (+0·002 mm.)	Clay (−0·002 mm.)
Sand	+75	−25	−25
Sandy Loam I	+60	−40	−10
„ „ II	+60	−30	−20
Heavy Sandy Loam	−75	−20	−30
Loam I	+45	+30	−10
„ II	−45	+45	−10
„ III	−60	+20	−20
„ IV	−50	+30	−20
„ V	−40	+40	−20
Silt	−30	+50	−20
Heavy Silt Loam	−20	+50	30
Clay Loam I	−60	−40	−30
„ „ II	+20	+30	−30
Clay	−70	−70	+30

NOTE.—A + sign is placed before a minimum limit, and a − sign before a maximum.

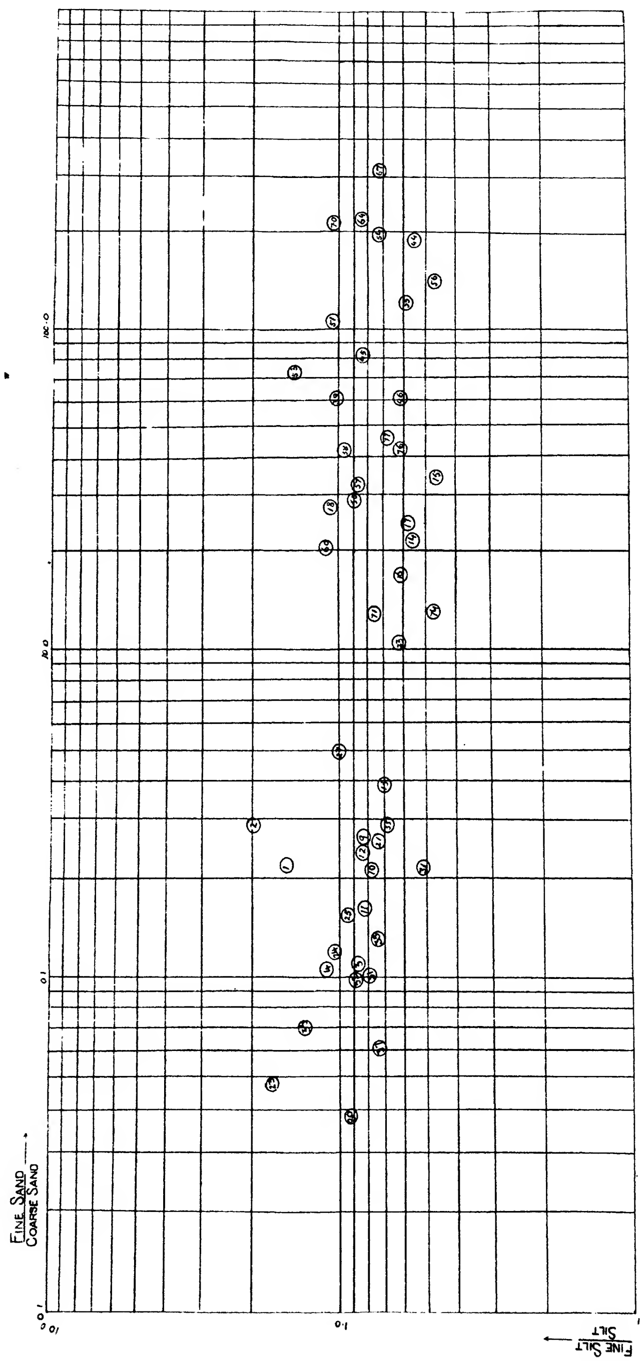
Diagram II contains analyses selected from Punjab soils and subsoils. Nos. 1 to 30 are Lyallpur soils: 31 to 38, Gurdaspur; 39 to 70, Montgomery: 71 to 75, Karnal; 76 and 77. Rawalpindi; and 78 to 84, Kangra.

This method of classification does not take account of the subdivision of the sand and silt fractions, which is effected in mechanical analysis, and therefore does not afford a complete representation of the constitution of a soil.

For classification, however, while the broad types thus distinguished may be sufficient for most purposes, it will be advantageous to devise a method by which the description of the mechanical type to which a soil belongs may be made as complete as possible.

For further differentiation of the soils falling within the compartments representing the main mechanical types, the method of plotting the logarithms of the ratio $\frac{\text{fine silt}}{\text{silt}}$ and $\frac{\text{fine sand}}{\text{coarse sand}}$ has

Diagram III



water-supply changes, but the relative importance of the part they play in crop production." The actual medium in which plant growth takes place is not the only factor. The character of the subsoil will have a great influence on the moisture equilibrium in the soil and data on the point should be collected. In the Punjab, where so much of our agriculture is dependent on irrigation and where climatic conditions are so constant, we have a great opportunity of determining the relative importance of these factors.

We may summarize the factors which must be studied in a soil survey under four heads. These are, firstly, the *constitutive* properties, by which is meant the unalterable properties of the constituent particles of a soil. Secondly, *additive* properties, by which is meant those properties of a soil which may be expressed as a sum of all the properties of the individual particles composing it. Thirdly, *colligative* properties, which, while depending on the properties and relative amounts of the individual particles, by reason of their interaction on one another, cannot in the present state of our knowledge be calculated. Fourthly, we may class together as *accidental or variable* all those properties which are under the control of the agriculturist. Under these four heads we may mention the following factors, which it is our ultimate aim to be able to correlate with the agricultural properties of soils mentioned under (5).

(1) *Constitutive.* The mechanical and mineralogical constitution of the soil and subsoil.

(2) *Additive.* Physical properties, *e.g.*, specific heat, density, surface. Total chemical composition.

(3) *Colligative.* Moisture equivalents. Pore space, transmission constants, available analysis, the determination of the composition of the soil solution.

(4) *Variable or accidental.* Organic matter content, aggregation (flocculation). Salinity, acidity, or alkalinity. Subsoil water level, etc.

(5) *Agricultural properties.* Behaviour of the soils with crops and manures, found empirically. Cultural treatment, etc.

The study of all these factors is necessary and no one class is of more importance than another. For the separation of soils into types, as a basis of classification, properties must be used which are truly constitutive. Additive properties merely give us the result of the summation of the variants; colligative properties we are not yet in a position to understand. In this paper the use of mechanical analysis is advocated for the purpose. At present there seems no need to make the broad fractionation of particles at present conventional, of greater fineness, but as our knowledge increases this may be necessary. All that is proposed in this paper is a method by which the ordinary mechanical analysis can be made of greater application for the description and classification of soils.

As regards the Punjab, steps are being taken to provide the necessary staff for this important work. The question of the organization of similar surveys in the other provinces of India will probably arise in time, and when this happens, it is to be hoped that it will be possible so to co-ordinate the work that results obtained in one province may be available and of use to workers in another. This is a question of standardizing methods and the provision of complete information of the soil types studied.

The actual survey work will probably best be conducted by the Provincial Agricultural Departments, but some central body for the co-ordination of results will be necessary. Without a proper organization and a specially trained staff, the characterization and study of soil types will be a very slow process. Moreover it is essential that the analyses should be rigidly comparable. If the lines of work were laid down, in the ordinary process of routine analysis, much information, which would be of subsequent use, would be collected. A proper organization would, however, probably amply repay the cost of its maintenance by its direct agricultural value and the speed with which a sound basis for the application of the Science, which it is the aim to secure for agriculture in India, would be attained.

SOME AGRICULTURAL ASPECTS OF THE HOSUR REMOUNT DEPÔT.

BY

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A REMOUNT DEPÔT naturally implies horses, and horses have to be fed. Consequently a large share of the activities of the establishment are devoted to the production of keep in all forms. The agricultural side of the depôt is thus an important one, and it is with this aspect that this note mainly deals. It would of course be possible to grow *all* the food, both bulky and concentrated, that is wanted, but for various reasons this is not practicable: it would imply a very much larger area, and more extensive staff and accommodation than is desirable. It is clear, however, that every effort should be made to produce the *bulky* fodder needed, owing to the expense of freight, and the special value that fresh fodder possesses, and so we find the land which forms part of the depôt devoted wholly to the production of fodder of one kind or another. Even of this, sufficient is not produced on the estate, and a considerable quantity has to be procured from outside, both dry and green.

The Hosur Depôt is situated on undulating red soil of lateritic origin, of varying depth and fertility. The lower lands, receiving the wash of the uplands, consist of a deep dark brown to grey sandy loam, while the uplands are sandier, and paler and redder in colour: both have the disadvantage, which is so often found on these soils, of baking very hard on the surface when dry, and at

the same time being uncomfortably sticky when moist. This does not make them any too easy to cultivate.

The area comprises both dry and wet lands, the latter being fed from a small rain-fed tank, and being naturally at the lower end of a valley. This circumstance increases the sharp distinction drawn above, between the dry uplands and the irrigated bottom lands.

An additional water-supply would have great value, but, in view of the fact that a boring has been taken down nearly 200 feet without success, it does not seem likely that such can be obtained.

The problem, then, is to produce the greatest quantity of nutritious fodder with the means available, and here the manure-supply is undoubtedly a great factor. The quantity available is much greater than would naturally be the case in any system of arable farming, and it is, from the circumstances of its production, undoubtedly of good quality. It is no doubt to constant heavy dressings of this substance that the change in colour of the bottom lands is largely due.

On these lands, lucerne is the staple crop, and a very good crop is obtained, though not without certain difficulties. Rats or moles damage the plants considerably by gnawing the roots, and gaps are consequently formed in the field. The crop also suffers, but not severely, from blight. These, and the plentiful crop of weeds, limit the life of the lucerne to about two years, after which the land is ploughed up and replanted. I was told that something over 200 lb. of (green) lucerne was obtained at a cost of one rupee, and the annual acre yield is in the neighbourhood of 25 tons. This yield is large, and the land is probably yielding its maximum. About the best method of sowing the lucerne, there is less certainty. The two methods found practicable are flat drills with frequent inter-cultivation, or beds with a cessation of weeding after the first six months, when the crop has become fully established. The question is perhaps mainly one of weeds, and these are certainly troublesome, but on such a short visit it is not possible to dogmatize. The absence of any rotation is what strikes an agriculturist, and it might be well to consider the possibility of a cleaning crop at

intervals; either a smother crop of thickly sown *Sorghum* (*jowar*: *cholam*) or Bulrush millet (*bajra*: *cumbu*) mixed with some pulse; or a widely spaced crop, in which intercultivation could be practised up to a late period. The former is probably the better as a heavy cut of fodder would be obtained at the same time. Rhodes grass and Guinea grass are also grown on a fairly large scale; the former has shown itself an excellent cropper.

A word may be said here about the cultivation, which is largely carried out by horse-power. For this of course no charge has to be reckoned, but a man is needed for each horse and a third for the plough so that the saving is not so great as it seems at first. The plough I saw in use was a long-breasted type, an old-fashioned Howard's Bedford plough, with two wheels, ploughing to a depth of four or five inches. It would be more economical to use a rather deeper plough, such as the S. A. E. or Steel Eagle, with or without fore-carriage, and by yoking more horses save on the number of men. There is little doubt that on both classes of lands, deeper cultivation would pay. In fact, trenching, which implies the thorough inversion of the soil to a depth of 2 feet, is occasionally practised with success, though at considerable expense.

The next class of lands are those lying fairly well down the slopes, but without facilities for irrigation, and these are mostly down to permanent grass. The treatment of these lands is usually to take one or more crops of hay off them, and then to graze them for a period. The fertility of the land, which is obviously high, is maintained by dressings of stable manure. These pastures are regarded with some suspicion by an agriculturist, to whom the cultivation and regular cropping of the land appears more natural. But there is little doubt that, in the conditions of rainfall and climate which obtain here, some of these pastures, for they vary very much in quality, are providing as much fodder as the land may reasonably be expected to produce. Provided grass can keep growing throughout the year, a condition which does not usually obtain on the plains, it can take full advantage of any rainfall that is received, which is not the case under any system of dry cropping.

It is when we come to the higher lands that the system of keeping the land in grass seems to fail. Not only are the grasses seen here poorer in quality, but they do not cover the ground, and of course give a very much poorer cut. Such lands would almost certainly bring in more fodder, if brought under the plough, though different opinions may be held as to the extent to which this change could be profitably introduced.

The matter is not easy, even with unlimited power, and a large supply of manure. The lands are unkind, and are a very good illustration of the need of judgment in deciding when the various operations should be performed, and the necessity for speed in carrying them out. A few days' delay may result in the land baking to an absolutely brick-like consistency, with the result that all chance of getting a good tilth is indefinitely postponed. And then the weeds have to be remembered. Certain of the deeper rooted grasses, among which *Cynodon dactylon* and *Panicum repens* may be mentioned, probably preclude any rotation of arable crops and pasture land, and it would be necessary to decide once for all which system was going to be adopted in the case of any particular field. The crops to be grown must be decided by trial: mixed fodder crops hold out the best chance of success, with "fall" ploughing as soon as the crop is cut—which could probably be done with a machine—in order to get the land up before the hot weather. This should improve the tilth, and kill the weeds, and it is in these two directions that the causes of the failure of the crops that have been tried must be sought.

The agricultural problems are, as I have tried to show, not without interest, in view of the special conditions which obtain. The few suggestions made above are put forward with some diffidence, as indeed must always be the case where the full agricultural year has not been experienced.

GOVERNMENT CATTLE FARM, HISSAR.

BY

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The following is a very brief history of the Hissar Farm since its establishment in the year 1809. In that year it was placed in the hands of Major Lumsdaine and used as a camel-breeding farm. In 1815 cattle-breeding and horse-breeding for the supply of stallions were added. Hissar appears to have continued as a horse-breeding centre up to 1848 or 1849.

In 1853 it was decided to restrict operations to breeding bullocks for transport and ordnance purposes, and in 1854 the farm was transferred from the Commissariat to the Stud Department. It was worked under Mr. Taylor, who held the appointment until his death in 1865. He was succeeded by Captain T. Robinson, who carried on the farm until 1874, when it came under the notice of the Stud Commission, with the result that it was again transferred to the Commissariat Department, in whose hands it remained until a committee appointed in February 1898 recommended that it should be handed over to the Civil Veterinary Department for a period of seven years, and on 1st April, 1899, it was taken over by that department and has remained in its charge since.

The first officer in the Civil Veterinary Department to hold charge was Major Gunn, who was Superintendent from 1st April, 1899, till 1902.

I took over from this officer and remained in charge until 11th June, 1912, when I was transferred to the appointment of Chief Superintendent, Civil Veterinary Department, Punjab, and

Mr. Branford took my place. The farm is situated in the Hissar District of the Punjab and comprises an area of 40,000 acres. The land before the Civil Veterinary Department took over had only about 500 acres set apart for cultivation, but now there are about 2,000 acres. These areas are divided into five blocks (Stables, Kherwan, Chaoni, Mundiawala, and Sully). These blocks have been enclosed and the fields carefully mapped out and numbered and the area of each noted on an iron plate. This work, owing to the great difficulty to be contended with in removing trees, jungle growth, levelling lands, etc., took some time, and the results have been very satisfactory.

The water-supply comes from the Western Jumna, but unfortunately the farm being at the tail-end does not always get the full amount necessary in spite of the water-courses having been improved. The crops chiefly sown are oats, *jowar* (*A. Sorghum*), *guár* (*Cyamopsis psoralioides*), and lucerne.

Oats, if required, are cut green and supplied to the stock, then allowed to grow again for seed and *bhusa*. Green *jowar* is also cut and supplied to the stock, and ensilage is also made with it. There are 25 pits for this purpose. There are large tracts for grazing, parts of which are set apart for making hay. The best grass is *Pennisetum cenchroides* [ver. *anjan* (Bagri), *dhaman* (Punjabi)].

The farm buildings comprise the following and are situated some miles apart.

(*a*) Home Farm Block, consisting of 15 large, walled enclosures with stabling and veterinary hospital, godowns, workshop, stackyard and Deputy Superintendent's house.

(*b*) Stable Block, consisting of 10 enclosures and stabling.

(*c*) Chaoni Block, consisting of 13 enclosures, stabling and Farm Overseers' quarters.

(*d*) Sully Block, consisting of 8 enclosures, stackyard, stabling, and Overseers' quarters.

At the Home Farm all stock requiring more careful supervision is kept; such as cows about to calve, ponies and donkeys about to foal, sick and debilitated animals.

At the Stable Block only heifers are kept in the cold weather. In the hot weather they are transferred to Kherwan. At the Chaoni Block all male and castrated stock is kept. This place is situated on the opposite side of the railway line, so that the stock is unable to get near the cows and heifers on the farm.

The Sully Block is about five miles away from the Home Farm and due north of it. In this place all the brood stock is kept.

Since the Civil Veterinary Department took over charge separate grazing paddocks have been made for pony mares, mules and donkey stock.

Owing to no policy of continuity and constant changes of officers in the Commissariat time, the Civil Veterinary Department took over a heterogeneous lot of stock of the following breeds: Gujarati (Kankreji), Mysore (Amrat Mahal), Sindi, Nagori, Hissari, and Nellore and their mixed offspring, with the result that heavy weeding had to be done. This work was started in 1902, when 1,500 cows were cast and new bulls selected with the view of evolving a type. This, as all breeders know, took time and the work was very difficult, as the registers kept up in the Commissariat time were very imperfect and I had to rely on types which I considered the best. All the Mysores or rather those showing Mysore, Nellore, and Sindi characters have been eliminated. The specially selected bulls are issued to the District Boards in the Punjab at Rs. 200 each, and are producing very good stock. Foreign buyers are constantly asking for permission to purchase bulls and cows from the farm. Two thousand rupees was offered for a bull last year and would have been taken but for shipping difficulties. Several young bulls have been sold for Rs. 500 each. Cows have been sold for Rs. 250–400 each. This all speaks for itself.

All male stock not up to the standard for breeding is castrated and issued to heavy batteries for Rs. 150 each. Heifers under standard are weeded and sold to zemindars and others are auctioned. The stock on the new farms in the Punjab has been purchased by the owners from the farm.

There are at present 1,500 cows, 1,900 male stock, 1,679 heifers, 81 pony mares, 100 donkey mares, 136 mules, 600 sheep, 197 donkey colts, 7 jacks, 2 pony stallions, 1 Arab, and 4 Arab mares.

With the 1,500 cows there is one bull to every 50 cows. The bulls are very carefully selected, and put with the herds at 4 years of age and weeded out if their stock is not good. A herd bull generally lasts until it is 10 years of age.

A register is carefully kept of all the stock, as is the case with the bulls. The cows are weeded out if their stock is not good. A cow is weeded out for age generally at about 12 years.

A small herd of Montgomery cattle is kept to supply bulls of this breed wherever required.

All the stock on the farm is branded on the left quarter with the age brand, and on the right quarter with a brand showing the serial number of the year in which it was born. These brands are entered in the register so that the pedigree of each animal can be traced. A detailed note of calves born is kept. If the calf is a weakling and dies or develops badly, etc., it is noted; if the bull or cow produces several of these it is cast. Barren cows, or cows giving insufficient nourishment to the calf, are weeded out as early as possible.

Bulls are issued to the District Boards between the ages of 3 and 4 years. About three months before issue they are taken up nose-strung, stall-fed, and handled to quieten them. All young stock is inoculated for black quarter at the age of 6 months when they are weaned. The females are transferred to the Stables where the heifers are kept and the males to Chaoni.

The heifers are carefully selected at 3 years of age, when the best are transferred to the herds. The males are castrated when they are nearly 3 years of age. They are then taken up nose-strung, stall-fed, and handled ready for issue to heavy batteries.

Pony mares are kept for two purposes—for breeding Arabs and mules. There are now 4 pure Arab mares on the farm and 1 very good Arab stallion. This scheme has only just been started and it is expected to be a success. The Arab stallion is also allowed to cover selected zemindars' mares. The mares for mule-breeding are a good lot and the mules produced are issued to mountain batteries; any not coming up to that standard are issued as maxim-gun and transport mules.

Donkey mares. This scheme was started in 1903. I was deputed to purchase the best country-bred mares available. These were crossed by an Italian jack, "Calcutta," for a short period, when a change was made and an American jack was used; then another stallion, "Farmers Boy," and other farm-bred jacks were used. The donkey stock on the farm is good—a very few of the old country-bred mares are left. The stock is carefully weeded and only the best fillies are kept, the rest are cast and sold. The male stock are also carefully selected before being transferred to District Boards as stallions. Mr. Branford is now inseminating donkey mares with pony stallion semen and one has given birth to a jennet.

Sheep-breeding. This scheme was started with a view at first of improving the size and quality of mutton. Dumba rams were crossed with Bikaniri and Bagri ewes. The produce is good, the sheep are bigger and the quality of the mutton good. Colonel Morgan then introduced the Merino and separate experiments were carried out with a view to improve the quality of the wool. The Merinos were crossed with Bikaniri and Bagri ewes. There is a marked improvement in the quality of the wool and the quantity produced per sheep is increased. Latterly I purchased some Lohi and Kali breeds of sheep from the Punjab. These are being mated with the Merinos.

There is also a small flock of pure-bred Merinos. It is found that the stock bred on the farm is smaller than its ancestor. The same is found to be the case in the hotter and drier belts in Australia, and in consequence the bigger framed Merinos of the more temperate climate have to be constantly introduced.

"NORTHERNS" COTTON.*

BY

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THE name "Northerns," as applied to cotton in Madras Presidency, is given to the indigenous cotton which is grown in the taluks of Dhone, Kurnool, Nandikotkur, Nandyal, Sirvel, Koilkuntla and Markapur in Kurnool District, the Native State of Banganapalle in the same district, Jammalamadugu and Proddatur taluks in the district of Cuddapah, and Tadpatri taluk in Anantapur District, the produce of which is brought into market at Kurnool, Nandyal, Proddatur, and Tadpatri. A small amount of cotton from the Nizam's Dominions also comes into the Kurnool market.

The crop is cultivated on both black and red soils and is always drilled. On the former soils it is usually sown in August–September with a small admixture of horse gram (*D. biflorus*), and is succeeded in the following year by *Sorghum* mixed with green gram (*P. mungo*). On the latter soils it is sown a little earlier and is usually mixed with Italian millet—two lines of millet to one of cotton. In this case also the succeeding crop is usually *Sorghum* mixed with one or more pulses.

Picking normally begins in February and continues into April. The operation is without exception done very badly. Work does not begin until about 10 A.M., when leaf, bract and boll are very dry, and no care whatever is taken to try to pick the cotton clean. On the contrary, the writer has seen capsules, leaf and small branches

* A paper read at the Fifth Indian Science Congress, Lahore, 1918.

deliberately included in the pickings. Moreover, each cooly collects his or her pickings in one heap, which is placed on the bare ground, thereby ensuring that a certain amount of mud shall be removed with the cotton. It is therefore not to be wondered at that this cotton has an unenviable reputation for dirtiness. Mill reports show that on the average the blow room loss with this cotton is about 18 per cent.

As normally grown by the cultivator, Northerns cotton is, in the main, a mixture of varieties of the two species *G. herbaceum* and *G. indicum*. On the black soils, *herbaceum* is, as a rule, the predominating species in the mixture, though sometimes *indicum* occurs to as great an extent as 50 per cent. On red soils *indicum* is the chief ingredient of the mixture, frequently to the almost entire exclusion of *herbaceum*. Other cottons are also found, but only to a slight extent. These are chiefly *G. hirsutum* (Cambodia and Dharwar-American) and *G. neglectum* (Gogupatti—Telugu; Pulichai—Tamil).

Both of these cottons, *herbaceum* and *indicum*, have been kept under observation at the Nandyal Agricultural Station ever since it was opened in 1906. From the experience thus gained, it is possible to classify broadly the characters of the produce of these cottons as follows:—

	G. herbaceum	G. indicum
Length	3/8" to 1"	3/4" to 1"
Strength	Weak to strong	Strong
Colour	White to creamy	Red
Feel	Very harsh to soft	Fairly soft
Ginning outturn	22 to 32%	22 to 26%
Seed	Clean to fuzzy	Clean to fuzzy

The term "clean" is applied to seed in which the fuzz is restricted to a small tuft at each end. It has also been noticed that the types with strong lint are always more difficult to gin, and that types with clean seed give lint which is long, strong, small in quantity, and, where the plant is of the *herbaceum* species, white.

The yield of each of these species has varied according to the season and the field on which it was grown. Comparisons, made under experimental conditions, of the two best strains of *herbaceum*

and the best strain of *indicum* with the local mixture have given the following results:—

	Yield per acre in lb. Kapas*	Lint
Local mixture	290	72
No. 2 (herbaceum)	280	84
No. 50 Do.	330	100
No. 14 (indicum)	340	6

* Unginned cotton.

These figures are the average over the last three seasons—1914-15, 1915-16, and 1916-17.

The produce of the local crop, after being harvested, has a more or less varied career before it reaches the buying firms, who purchase cotton for spinning purposes or for export and sale to spinners. Ginning is done in Indian-owned gins either out in the district or in the market town itself. These are badly managed, and, as the owners keep a sharp eye on the daily outturn, the lint is frequently damaged and always contains a fair amount of seed, all of which helps to make the blow room loss as great as it is. The use of an opener before ginning is a rarity, and owing to careless feeding *kapas* is frequently mixed with the lint.

Kapas produced on black soils usually gives a fairly white lint, while the produce on red soils usually gives a distinctly red lint. The lint is therefore sold under two names—"White Northerns" and "Red Northerns"—the difference in price usually being from Rs. 5 to 10 in favour of the former.

Conditions of trade.

At Nandyal the trade runs on the following lines.

Parties concerned—

(1) *The producer.*

(*a*) The small ryot who, at the time of harvest, is badly in need of money and who, therefore, cannot wait his time for selling and has to sell his produce as *kapas* and at a low rate. In this class are to be found a few ryots who have taken advances from middlemen and have contracted to sell their produce at a rate agreed upon.

which is generally considerably lower than that ruling at the time when delivery is made.

(*b*) The bigger ryot who can afford to wait for his price or to have his produce ginned, and is therefore in a better position to bargain than are members of class (*a*). Some members of this class are village middlemen.

(2) *The village middleman.*

He buys *kapas* and has it ginned and is mainly responsible for the mixing that is done, either because he does not take the trouble to keep different qualities apart, or because he purposely mixes a good quality with a poor to make a larger sample which will pass as good or will be only slightly allowanced. The middleman sells on contract to the dealer and to the firms, but also sells on ready delivery.

(3) *The dealer.*

The dealer makes contracts on the one hand with firms to deliver, and on the other hand with middlemen or ryots of class (*b*) to receive cotton of a certain quality, at a certain rate, on or before a given date. He also buys cotton and speculates on the market.

(4) *The firms.*

There are three European firms two of which own presses, and one Indian firm which owns a press and a ginning factory, but which is really only a combination of dealers who sell to any of the other firms. Buying is also done by agents of other Indian firms, and of Japanese firms who, however, cannot be considered regular buyers.

System. The system is the pressed bale system, *i.e.*, the firms deal in lint and do not make final payment until the lint has been cleaned and pressed and weighment of the bales made. Advances are given when lint is brought but cannot be pressed for some time.

Manner in which lint reaches the firms.

(1) The firms make forward contracts on the lines indicated above, chiefly with dealers to whom some firms pay brokerage, but also with ryots and with middlemen. Warning is usually issued about a week before the final date on which delivery is to be made,

and, if it is asked for, an extension of time is generally given, but if delivery is not made, the firm can buy in the open market on the day on which the contract expires and charge the contractor with the difference between the contract rate at which they bought, or they can demand the difference between the contract rate and the rate prevailing on the day on which the contract expires.

(2) The ryot or middleman watches the market. When he thinks the price is high enough to suit him, he brings his cotton for sale. He leaves his cart on the roadside, while he goes round making inquiries as to what the rates are and who is likely to pay him the best price. Having decided whom he will try first, he brings his cotton into the compound and offers it for sale. It is examined and rejected, or the bargain is struck. If rejected the ryot will try elsewhere and may get a dealer to offer the cotton against one of his own contracts. The dealers who have bought on speculation also watch the market and will tender cotton which they have stored in their godowns, either against contracts, or for separate sale, whichever may be more profitable to them.

At the other markets, except for the few differences noted below, the conditions of trade are very similar.

Tadpatri. Direct dealings between producer and buying firms are practically non-existent.

Kurnool. Direct dealings between producer and firms are fairly common, and as the market is small the village middleman is much less in evidence. Buying is on the loose bale system.

Proddatur. As at Kurnool, but both systems are in vogue. When cotton is bought loose, the buyer retains the gunnies in which the cotton is packed and is entitled to make the following deductions: about 1½ per cent. on the gross weight for dirt, and 1 per cent. on the nett weight for sample.

The quantities of cotton coming into these markets are approximately as follows:—Nandyal, 30,000; Tadpatri, 10,000; Proddatur, 8,000; and Kurnool, 6,000 bales of 400 lb. each.

The above gives in broad outline the position that must be attacked if it is desired to bring about any improvement in the present state of affairs. By improvement is meant here an alteration

which shall result on the one hand in an increased profit per acre to the producer, and on the other in the buyer being offered a better article.

Such improvement may follow one or more of three main lines:

(1) Improvement in the methods of cultivation, harvesting, etc;
(2) improvement in the plant itself; and
(3) improvements in the method of marketing.

IMPROVEMENT IN THE METHOD OF CULTIVATION, ETC.

It is difficult to devise changes in the present methods of culture, manuring, harvesting and preparation of produce for sale which will bring any solid benefit to the cultivator. The seed-rate used is not excessive, and topping, thinning and growing unmixed with horse gram have not shown any advantage over the local practice.

Manuring with cattle or sheep manure, or by preceding the crop with a crop of Bengal gram, all improve the yield. The cultivator is, however, debarred from adopting these practices extensively owing to the fact that cattle and sheep manure are to be had in only limited quantities, and because Bengal gram is an uncertain and not very profitable crop, and its introduction into the rotation would necessitate cotton being grown once in three years instead of every other year as at present. The practice of growing groundnuts is, however, extending rapidly, and it is likely that this crop will play the part that Bengal gram has failed to do.

With regard to harvesting, a very great improvement might be effected if the coolies were paid daily wages in grain or in money instead of a definite proportion on the day's picking as at present; and if picking could be started in the early morning while the bracts and leaves are still damp with dew. This arrangement, if the pickers were carefully supervised, would result in very little leaf being picked with the cotton. Unfortunately, with Northerns cotton, picking is not a gradual process, the bolls mature rapidly and evenly, and, as a rule, three pickings with an interval of about a fortnight between each will see the harvest finished. The demand for labour at these times is therefore very keen, particularly so as the cultivator

has to bear in mind that if he does not pick his crop himself, some unauthorized person will do it for him. As labour is scarce, the pickers can more or less dictate their own terms, and as they are usually women and have to attend to household duties before going out to work in the fields, it suits them to start late, work through the heat of the day and return early.

They prefer to be paid a fraction of their daily pickings as wages, as they can in this way earn higher wages. This arrangement also suits the cultivator, as he is relieved of the necessity of keeping his labourers up to the mark, and is able to get his crop harvested quickly.

It is probable that a few isolated cultivators would be able to make the change described above; but it is improbable, under present conditions, that they would profit by so doing.

As regards the preparation of the produce for sale, an improvement might be brought about if the cultivator could be induced to market his crop in two qualities. This he could arrange to do either in the field, by having two gangs of coolies, one to pick the good, well opened bolls, and the other to pick the stained and badly opened bolls, or by picking the crop over after it has all been harvested. The whole system of marketing is unfortunately against the adoption of this practice. The writer has tried this plan more than once, and has found it to result in a loss every time. When offered two qualities like this, all the buyer does is to calculate what he would have to pay for the same total quantity at the ruling rate, and then offer a rupee or two more for the better quality and a considerably lower rate for the second quality, so that he pays a little less or at least no more than if the lot were all of one quality. The seller is left with a loss equal to or greater than the extra cost of preparation.

Under this head, preparation for sale, defects in, or connected with, ginning must be considered. These are usually four in number. In the first place, the mechanic who is responsible for the proper working of the plant is usually changed too frequently. For motives of economy his services are dispensed with at the end of the season until the next working season, when the same man may be employed

or not as the case may be. A ginnery ordinarily pays well enough to enable the owners to retain the mechanic's services throughout the year. It is false economy not to do so. An extension of the working season would obviate this difficulty. With the spread of the groundnut crop, many gin owners are fitting up decorticators, and are so making a more economical use of their plant.

Secondly, only a few ginneries have openers, and those who have do not use them properly. The main reason for this is that the cultivator looks askance at any operation which involves the loss of weight which the proper use of an opener undoubtedly does. A remedy which some of the firms are adopting is to offer a slightly enhanced rate for cotton known to have been ginned at a ginnery where an opener is in use.

Thirdly, the gins are, as a rule, run too fast and, with improperly set knives, the lint is damaged, the seed is broken and is carried through with the lint. The only satisfactory remedy for this at present is for firms which are particular on this point to buy *kapas* and do their own ginning.

Lastly, the godown accommodation at these ginneries is exceedingly limited, and every year much lint is spoilt owing to the *kapas* having been exposed to rain and ginned while still damp. The only remedy for this is to compel gin owners to provide sufficient godown accommodation for the produce brought to them for ginning.

Improvement of the plant.

In attacking this problem, the object to be aimed at is the production of a cotton which will meet the requirements of (1) the ryot who sells his produce as *kapas*, (2) the ryot who sells as lint, and (3) the final buyer. The wishes of the first two parties are easily diagnosed : neither care very much what the quality of the cotton is, provided that it is readily saleable ; both wish a heavy yield of *kapas* per acre, and the second wishes a high ginning outturn in addition. It is when considering the requirements of the third party that puzzling features arise. A careful study of the market drives the observer to the inevitable conclusion that class, *i.e.*,

colour and cleanliness, is of more importance than quality, *i.e.*, length and strength of staple. Evidence of this is to be found in the difference in price between Red Northerns and White Northerns, the former of which is lower in class because of its red colour, but better in quality. A cotton, however, which combined in itself high yield of *kapas*, high ginning outturn, good class and high quality would satisfy everyone and would attract more buyers. With the object of finding such a cotton the work at Nandyal has been carried on.

The method adopted in doing this work is as follows :—

Seed of the local mixture is obtained from a cultivator and is sown on a separate plot. When the crop is in flower it is examined and a number of the most prolific plants are marked. As many flowers as possible on each of these plants are selfed. This is very simply done by sewing up the apex of the unopened corolla the evening before, or on the morning of the day on which the flower would naturally open. The produce of each plant is then collected separately, the *kapas* from selfed and unselfed bolls being kept apart. This is examined both as *kapas* and after ginning, and the best plants are kept for further examination. Next season the seed of these single plants is sown in small plots, giving a spacing of 2′ each way for each plant, so that it may have full opportunity to develop and show its type of habit. These plots are then watched to see if each strain is pure, and as many flowers as possible in each are selfed. If any of the strains are impure, selection is made as in the beginning. The produce of the pure lots is again examined, and a further weeding out takes place. In the third year there is usually enough seed of the final selections to make a comparative test and to sow a plot to give seed for next year's sowings. The comparative test is made by sowing three lines (long enough to make a plot of 4 cents) of each strain in succession, and repeating the series five times. The seed plots are sown as far from one another and other cottons as possible, and picking for seed purposes is done from the middle of the plot only. The comparative test is carried on for at least four years, and as soon as enough seed is obtained the selections are sown on a large enough area to give sufficient lint for a spinning test to be made.

The defects that have occurred in this system are inability to deal with anything but a limited number of selections, and the omission of hybridization. Either because of this, or because the ideal plant described above exists only in the imagination, the fact remains that the results obtained have not been very satisfactory. It has been possible to get three out of the four good qualities required combined in one plant, but not all four. For example, No. 50 combines high yield, high ginning outturn, and good class, but poor quality; and No. 14, high yield, good quality, and good class, but low ginning outturn. The problem is big enough and important enough to occupy fully the energies of one man.

Improvement in the method of marketing.

The outstanding features of the present methods of trade are:—(1) the system of making forward contracts, (2) indirect dealings between firms and producers through the agency of middlemen and dealers, (3) direct dealings between firms and producers, (4) the pressed bale system, and (5) the loose bale system.

The forward contract system.

Buying on this system is carried on practically right throughout the season. It has this advantage, provided that the dealer is reliable and financially sound, that the buying firm is enabled to make fairly certain that whatever conditions prevail they shall have a share of the crop even before it comes into the market.

Cases, however, occur when the dealer finds that it will pay him (for the time being at any rate, whatever may be the result in the long run) to default and hold his cotton for sale at a later date.

The system has the defect that the buyer does not see what he has bought until the cotton is tendered against the contract. In theory this does not matter very much. All that the buyer has to do is to reject or heavily allowance the cotton if it is not up to the contract quality. In actual practice this cannot be done to any great extent. Any single firm which seriously adopted this attitude would find that it could not get cotton. If all the firms concerned

would agree upon what qualities they would reject and upon what allowances they would make for qualities below their standards, and at the same time would agree to pay more for qualities above their highest standard, they would get better quality. As the system works at present, not only does the standard differ from year to year as is to be expected, but it differs from time to time during the season. Cotton is, in fact, passed, rejected, heavily allowanced or lightly allowanced, as much on the need of the firm concerned for cotton, and on the ability of the seller to stand out against allowances, as on anything else. The system is, in fact, a direct encouragement to the dealer in *kapas* to mix as little as possible of a good quality with as much as possible of a poor quality in order to get a big lot of lint which will be passed with little or no allowance. This he does with great regularity. Red Northerns sells at Rs. 5 to 10 less than White Northerns. The middleman buys up *kapas* of our No. 2 cotton which is white, and mixes it with *kapas* of Red Northerns in the proportion of about 1 : 2. He sells the lot as good White Northerns.

Indirect dealings between firms and producers.

The main advantage of this method of doing business is that the firm deals with only a few men, which allows fairly sound reliable men being chosen, who contract to supply large quantities of cotton.

It has the disadvantage, however, that it places the dealers in a position which will permit them to hold up cotton and prevent a firm from getting any if they so desire.

A further disadvantage is that the dealer has not much interest in seeing that cotton tendered is of good quality, and the system lends itself to fraud. Unless a dealer tenders against a contract cotton which he has purchased outright, when he will fight tooth and nail against allowances, he has little personal interest in what happens to the cotton, so long as it is accepted by the firm. The reason for this is that if the firm accepts the cotton with an allowance, the deduction is made from the dealer's client and the dealer himself is not affected.

Direct dealings with ryots.

This method has the disadvantage that transactions for small quantities have to be entered into, and it is not always easy to get at the ryot if he happens to fail to fulfil his contract.

It has the advantages that it is easier to get at the truth about a cotton from a ryot than from a dealer, that a good connection can be built up among ryots, and that, while the ryot would gain more by the elimination of false weighments, the firm would not pay quite so high a price. With the practically total cessation of the practice of hand-ginning now, it is more difficult than formerly to get into direct communication with the ryot. The gin-owners are as a rule also dealers, and prefer to gin for their own middlemen and other dealers. Unless, therefore, a ryot is a man of some standing, he finds it difficult, if not impossible, to get his *kapas* ginned at a power gin, unless he consents to part with the lint to a dealer.

The pressed bale system.

The advantage of this system is that the firm does not pay for the cotton until it has been cleaned on the cots. There is, therefore, no risk of the firm buying sand, stone, weights, etc., at the price of cotton. It has the disadvantage that it does away partly with the benefit of doing business with dealers, as the latter are no more prepared to take the risk of buying other things than cotton than are the firms. All the small lots bought by the dealer's clients have therefore to be pressed separately, and the dealer pays on the cleaned weights just as the firm does. When this has been done the firm gets the bales, but in the meantime has had to put up with the inconvenience of baling a number of small lots instead of one large consignment. With this exception the disadvantages are on the side of the seller and his clients. Until the lint is pressed, final payment cannot be made. The ryot who has sold direct or is a dealer's client has therefore to wait about until the cotton is pressed before he can finish his business and get back to his land. He frequently has to wait for some time, which means trouble and expense to him, and it may interfere with his preparatory cultivation.

The loose bale system.

This system has the advantage over the pressed bale system in that the buyer does not need to bale a lot of small quantities separately, and the seller has not to wait until pressing is over before he can complete his business. The deduction made for dirt is calculated to cover approximately the loss which is incurred in cleaning prior to pressing. The other two features, the gunnies becoming the property of the buyer and the deduction for sample, appear to be accidental grafts on to the main system. In the first case, the practice appears to have arisen out of the desire of the ryot to have the transaction completed and done with, so that he does not need to return and recover his gunnies. No doubt the value of the gunnies was and is included in the price paid for the cotton, but the practice has had this result that in very many cases the cotton is packed in very loosely woven poor quality gunnies, which the buyer finds difficulty in getting rid of. The practice of making a deduction for the sample is one that there appears to be little justification for, and which the seller might well object to allow.

The loose bale system has the disadvantage that the buyer has to take the risk of foreign materials being added to make up weight. As, however, each man who tenders cotton is known, this trick is one which cannot in general be played more than once and results in a very handsome deduction being made next time the perpetrator brings cotton for sale. To the ryot the loose bale system appeals strongly, as he is not kept hanging about for a long time together before his business is finished.

Summary.

These then are the main features of the present system of marketing. It will be seen that the main defects are—

(1) the lack of real competition owing to the liability of a greater or less proportion of the crop being " bound " before the actual season begins, and the seller having to come to a buyer instead of all the buyers to the seller;

(2) the prevalence of mixing; and

(3) in the case of the pressed bale system, the delay in settling business.

The question has now to be considered as to whether any other system could be substituted for the existing system.

Freer and more open competition would be gained if the sellers brought their produce to one place, where each man's lot would have to stand comparison with his neighbour's and to which buyers would come to make purchases. This indicates the necessity for the establishment of an open market.

Mixing can best be detected before ginning. The produce must therefore be sold as *kapas* and by the producer. So long as there is a difference in rates, as there is at present between Red Northerns and White Northerns, and so long as the produce is bought and sold as lint, so long will the middlemen mix these two qualities together and endeavour to sell the mixture at the higher rate. The ryot must therefore be induced to bring his *kapas* into the market for sale. Another reason for having cotton brought for sale in the form of *kapas* is that, until the Agricultural Department can produce a cotton with all the four good points mentioned above, it will be necessary for the firms to offer higher prices for a good quality cotton, defective in yield or ginning outturn. Unless they buy this cotton as *kapas* and gin it themselves, they cannot be sure that they are buying a pure article, and in addition will have to put up with the cotton being damaged in ginning.

With this system the ryot could either sell outright or on the condition that his seed be returned to him and he be paid on the lint obtained.

In the first case his business would be completed in a day if he sold the day he brought the cotton to market; and in the second he would, if he had to wait at all, have to wait no longer than he does at present for ginning. He would be spared the second wait for pressing.

With this question of the open market is bound up the question of honest weighment. There is no doubt that there is considerable dishonesty over this operation. The ryot is in the habit of hand-ginning a small portion of his produce in order to test the ginning

outturn. If therefore he could be sure of the weights of his *kapas* he would have a fairly shrewd idea of how much his lint ought to weigh after the *kapas* was ginned. The most feasible plan would therefore seem to be to have the *kapas* weighed publicly in the open market (probably a platform machine with a dial as used in auction marts at home would be most satisfactory) and frequent check of weights used outside the market.

CONCLUSIONS.

To sum up, the requirements for the improvement of Northerns cotton are (1) more time and research to be given to the improvement of the plant, (2) better harvesting and preparation for market, (3) better ginning, (4) establishment of an open market to which cotton would be brought as *kapas*, and (5) the establishment of ginneries properly fitted and constructed, either owned or controlled by the buying firms. (1), (3), (4), and (5) are well within the bounds of possibility; (2) will require a large amount of spade work to be done by the department, backed by substantial aid from the buying firms, before any improvement along this line is likely to be brought about.

THE IMPROVEMENT OF "TINNEVELLIES" COTTON.*

BY

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THE Tinnevelly tract, with which the subject of this paper is concerned, comprises the three southernmost districts of the Madras Presidency. Cotton is here cultivated on an area of about 600,000 acres. The tract is bounded on the north by the Periyar irrigation project, on the east and south by the sea, and on the west by the Ghats. The compact and somewhat isolated position of the tract largely accounts for its individuality, for the conditions obtaining here differ in many respects from those in cotton tracts of other parts of India.

COMMERCIAL "TINNEVELLIES" COTTON.

"Tinnevellies" cotton is essentially a dry-land crop cultivated under unirrigated conditions on black soil of varying depth and natural fertility. It is, in reality, a mixture of two distinct varieties of cotton known locally as *karunganni* (*Gossypium obtusifolium*, Gammie), and *uppam* (*Gossypium herbaceum*). The distribution of these two varieties within the tract is of interest in that *karunganni* is the more commonly cultivated in the south and *uppam* in the north. In the central parts we generally find mixtures of these, but stray plants of either variety may be found in almost any cotton field. Until recently it was only in very rare

* A paper read at the Fifth Indian Science Congress, Lahore, January, 1918.

cases that pure crops of either variety could be seen. The distribution of these two varieties is believed to be a natural one determined by the habitat best suited to each. The south is nearer the sea ; the sea breeze blows more frequently and strongly than in the north, and the rainfall in the south is generally low and precarious.

The average crop of "Tinnies" marketed annually is about 100,000 bales of 400 lb. each. It is sown in October-November with the N.-E. monsoon rains and harvested between March and August. With favourable summer rains the crop gives a good second flush.

"Tinnies" cotton averages about ⅞ inch in length. It gives an average lint outturn of 25 per cent., and an average acre yield of about 300 lb. of seed cotton. It has a slight creamy colour, and is strong. F. G. F. "Tinnies" can spin a good 25's yarn, and is valued in normal times on the Liverpool Exchange at about ½*d.* per lb. below "Middling Americans."

Lines of improvement.

The improvements effected in "Tinnies" cotton since the department first undertook the work falls under five main heads :—

Firstly, the selection of improved strains ;

secondly, the propagation of the best selected strains ;

thirdly, the marketing of these strains ;

fourthly, the introduction of drill cultivation, and the manufacture and sale of drill-sowing and interculturing implements ; and

fifthly, the eradication from the "Tinny" tract of a low grade cotton of the "neglectum" type, known locally as "pulichai."

The last two subjects are of sufficient importance to demand separate chapters, and this paper will mostly be confined to the work done up to the end of the 1917 season on the selection, propagation, and marketing of unit strain selections of cotton in the "Tinny" tract.

SYSTEM OF SELECTION.

The selection work is done entirely at the Koilpatti Agricultural Station, and though the system adopted claims no pretence to being highly scientific yet it serves a useful purpose, as evidenced by the ends attained. The *modus operandi* may be of interest to those engaged on similar work elsewhere.

In 1908, Mr. Sampson, who was then in charge of the work, after examining a large number of plants, decided to confine selection work to two main types of *karunganni* as this species had proved to be much more variable in a number of characters than the *uppam* species. One of his types was small, bushy, early flowering, and possessing a large number of vegetative branches. Another was tall, late maturing, and bearing mostly fruiting branches. Since then, and up to the 1917 season, the produce of a large number of plants from these two main types bearing superior characters have each year been bagged separately in the field. A small bag is tied round the neck of the selected plant, and both the bag and its contents are left in position until the end of the main picking season.

The examination of the seed cotton from these single plant selections involves the scrutiny of a number of characters, amongst which are included—

length of staple,
strength of staple,
ginning outturn,
fineness,
whiteness,
silkiness,
and uniformity of staple.

More recently the yield of seed cotton per plant has been given greater consideration than formerly. Only those plants are retained and propagated which show all-round excellence.

In the course of these investigations plants have been discovered with a ginning outturn as high as 36 per cent. against an average of 25 per cent. for "Tinnies," and others having a staple

of $1\frac{1}{4}$ inches as compared with an average of $\frac{7}{8}$ inch for "Tinnies." The available evidence seems to point to the fact that in seed cotton excellence in length of staple and in ginning outturn are to a certain degree mutually antagonistic. Very few unit strains have been discovered which combine these characters. The selected strain having a staple of $1\frac{1}{4}$ inches had a ginning outturn of 25 per cent. only; and the strain which ginned at 36 per cent. had a relatively short and coarse staple. It naturally follows, then, that of the 500 odd plants selected each year a very large proportion has to be discarded.

Having survived this preliminary test the question of propagation arises. The single plant selections which do survive (generally about 50 in number) are in the second year grown comparatively in three-line contiguous comparative plots, each bearing about 75 plants. Those which do not breed true to type, or which are in other respects inferior, are at this stage discarded. Here again, as at all subsequent stages, the comparative yield of lint per unit area is given due consideration. The best "three-line" selections are propagated on to the "field-plot" scale of 5 cents in the third year when they are again tested against each other, and on to the "field-crop" scale of one acre in the fourth year. By this time only some two or three selections remain. In the sixth year these are grown on contract by ryots in the usual ryotwari manner, except that they are drill-sown. The seed cotton is purchased by the department at special rates, is ginned at the Koilpatti farm, and tested in the local spinning mills. The best strain is then propagated in the seventh year on the maximum scale of about 400 acres under "seed-farm" conditions on contract by ryots. The seed cotton from the whole of this area is again purchased and ginned by the department, and the seed sold to the public. Even then, in its eighth year, a unit strain selection cannot be grown on a sufficiently large area to command the attention of exporting firms, as distinguished from local spinners. In the ninth year the outlook is materially changed, for the unit strain can then be grown on an area exceeding 10,000 acres, and the produce can be marketed and shipped in bulk.

"COMPANY" COTTON.

Such, in brief, is the outline of the history of the unit strain selections now being marketed on a commercial scale as "Company 2" and "Company 3" (or as "Karunganni 2" and "Karunganni 3," as some firms prefer to call them). The former first arrived at this stage in 1915, and the latter in 1916. This stage is, perhaps, the most critical in the history of any unit strain selection. Up to this time exporters would offer no premium for this cotton and the produce was sold to the local spinning mills at a nominal premium which rose steadily from Rs. 3 per *candy* of 500 lb. in 1913 to Rs. 7 in 1915. We feel our indebtedness to these mills for the support thus given, without which the progress of the work would have been seriously handicapped. This experience may be of use to those engaged in similar work in making arrangements for marketing selected cotton, when available in small lots only, to local spinners rather than to exporters. When such cotton becomes available in thousands of bales the premium offered will adjust itself commensurate with the intrinsic value of the cotton. Exporters become interested and competition follows.

MARKETING.

At the commencement of the 1916 season a circular letter was issued to all the local cotton firms intimating them that there would be on the market that year some 1,600 *candies* (of 500 lb.) of "Company 2," and 400 *candies* of "Company 3." Samples of both types were sent to each firm. They were further informed that the department could arrange the delivery of the major portion of these cottons in a pure form. On the strength of this guarantee premiums were offered by practically all the local firms. These premiums varied from Rs. 4 to Rs. 10 per *candy* of lint, in excess of the ruling market price of "Tinnies" on the date of delivery or of contract.

Cotton improvement in Tinnevelly has the Koilpatti Agricultural Station as its nucleus. The Farm Manager, in addition to his more legitimate duties on the farm, is responsible for the general supervision of district work throughout the tract which is

divided into four circles each in charge of an Agricultural Demonstrator. When offers of premiums were received by me from the cotton firms early in 1915, these were immediately communicated to the Circle Demonstrators. They, in their turn, conveyed the happy news to those ryots who had grown "Company" cotton. The ryot is left to decide for himself as to which firm he will take his cotton—but he is no such fool as not to take it to the highest bidder. This led to an interesting development. Many of the firms were anxious to procure sample consignments of these cottons, at least in sufficient quantity to place them on the Indian and foreign markets where "Tinnies" are commonly used. Competition led to over-bidding, and the 1916 season closed with a premium of Rs. 16 per *candy* being offered for unlimited quantities. The competition was so keen that I received open offers from more than one firm of a premium of one rupee in excess of what any other firm was prepared to give. This made my position impossible. Needless to say, such offers were discountenanced, and only offers of specific premiums expressed in rupees were communicated to the Demonstrators. I here desire to emphasize the fact, and to make it absolutely clear, that at no stage has there been any hankering whatsoever for enhanced premiums. Subsequent to the issue of the original circular letter already referred to, no firm was invited to raise its premium, neither was it informed what premium was being paid by any other firm. All offers of premiums, subsequent to those first communicated in reply to my circular, were unsolicited.

I have dwelt at some length on this topic because in a tract where the competition is already keen it is so easy to give offence to or clash with the interests of cotton firms in such a manner that they may refuse to continue to give their support to cotton improvement work, without which it would be extremely difficult for the department to continue its efforts.

Now of the 2,000 *candies* of lint of what has been designated "Company" cotton, reported to the various firms to be available in 1915, only some 120 *candies* were grown on contract by ryots for the department for propagation purposes. Registers had, however, been maintained noting the names of those ryots to whom

seed had been distributed at the time of sowing. It was incumbent upon the department, therefore, to devise some means of ensuring the delivery direct to the firms of "Company" cotton grown privately by ryots. With this end in view a system of certificates was instituted whereby the purity of the seed cotton was guaranteed. These certificates guarantee the purity of the seed cotton delivered. They ensure that the ryot will receive the maximum premium for his produce. They further ensure that, as long as the cotton is available in sufficient bulk, it will be brought to the notice of foreign markets in its pure state—at least, I should say, by those firms who would prefer not to use it for grading up inferior quality "Tinnies." Other useful purposes which these certificates incidentally serve will be alluded to later.

This last year, 1917, the quantity of "Company" cotton on the market was estimated at about 12,000 *candies* of 500 lb. The greater portion of this has naturally been delivered to those firms which were most anxious to procure it, that is, those which paid the highest premium. Agents of other firms tell me that a premium of Rs. 16 per *candy* is inflated and does not truly represent the intrinsic value of this cotton. For, they say, at present rates, this premium involves an aggregate cost exceeding that paid for Middling Americans. I have been informed on the authority of the agent of an Indian cotton mill who has experience of this cotton that by using it for the usual "Tinnies" counts of 25's yarn there is a saving of 10 per cent. in mill production attributed to the regularity of staple and cleanliness. It so happens that this saving, in itself, more than compensates the mill-owner for the premium of Rs. 16, apart altogether from the enhanced value of the cotton due to its higher spinning qualities. In 1917 the premium paid has varied from Rs. 10 to Rs. 15 per *candy* of 500 lb. of lint. This slightly decreased premium is to be attributed chiefly to the receipt of unseasonal rains which were adverse to the whole "Tinny" crop, not excluding "Company" cotton. The latter was not so conspicuously clean as in 1916. And cleanliness and whiteness, unfortunately, take precedence with some exporters over quality of staple.

Average samples of the 1917 "Company" crop were again tested for their spinning qualities, and it is pleasing to note that they have maintained their high standard of 40's counts.

It remains to be seen how the premium offered for "Company" cotton will fluctuate in the future. But I have a shrewd idea that, before many summers have passed, "Company" cotton will be grown on such a scale that it may be purchased at just a nominal premium, if any, even when certified to be pure. There have been many instances in the past season where "Company" cotton has been delivered to firms unaccompanied by certificate and no premium paid for it. I have in mind one outstanding case where an exporting firm submitted for valuation to arbitrators in the Liverpool Cotton Exchange samples of—

	Rs.	per
(*a*) "Ordinary Tinnies," which was valued at	189	*candy*
(*b*) "Good Average Tinnies" which was valued at ..	197½	of 500
(*c*) "Company 2" (certified) ,, ,, ,, ,, ..	197½	lb. of
(*d*) "Company 3" (certified) ,, ,, ,, ,, ..	199	lint.

The astonishing part about these valuations is that "Company 2" was valued at the same price as "Good Average Tinnies." This was of special interest and certainly demanded further investigation. The origin of the "Good Average Tinnies" was enquired into, and it was discovered that a large proportion of the cotton delivered as such by the dealers at the ginning factory was uncertified "Company 2" grown from seed sold to the public in the previous season.

CULTIVATOR'S PROFITS.

In order to reap maximum profits the ryot who grows "Company" cotton relies on three separate factors, namely, the superior quality of the lint, the high ginning percentage of the seed cotton, and on the premium which the seed commands. The average acre yield of seed cotton is only slightly higher in the case of "Company" cotton than in ordinary "Tinnies."

Firstly, then, an average premium of Rs. 12 per *candy* of 500 lb. means an additional profit of Rs. 2 per acre.

Secondly, cotton giving an average ginning outturn of 32 per cent., as compared with 25 per cent. for "Tinnies," means an additional profit of Rs. 9 per acre. It is this factor—a high ginning percentage—that will make it profitable to the ryot to grow "Company" cotton in the absence of any premium. This further explains why middlemen find it profitable to pay him a premium as high as Rs. 3 per *pothie* of 250 pounds for seed cotton of "Company 2" ginning at 28–29 per cent., and Rs. 5–6 for "Company 3" ginning at 31 to 33 per cent. At this price the middleman still makes a profit even when he receives no premium for the superior quality of the lint, for certificates guaranteeing purity are issued to actual cultivators only.

Thirdly, there is a demand at present for "Company" seed at a premium, and this means an additional profit averaging about Rs. 4 per acre.

This makes an aggregate net profit of Rs. 15 per acre in a normal season, in excess, I may point out, of the profits that could be made by growing ordinary "Tinnies." These large profits were made by the relatively few who grew "Company" cotton in 1916, and this served in 1917 as an excellent advertisement. The demand had become so great in 1917 preparatory for the 1918 crop that the seed available was quite inadequate to meet the demand. The 1917 crop of "Company" cotton was estimated at about 70,000 acres.

Co-operative sales.

It has now been made sufficiently clear that Mr. Sampson has succeeded in turning out high grade varieties of cotton which can be profitably grown on the local black soil, and which are superior to anything the ryot had hitherto at his command. It still rested with the department to organize—

(*a*) a system by which these cottons could be marketed in an unadulterated form to the mills on a wholesale scale; and

(*b*) a system by which any unit strain could be propagated on the maximum scale in as short a time as possible.

A branch of work which has received much attention for the past four or five years is the co-operative sale of cotton by the cultivators direct to the firms. Incidentally, the success that has attended this branch of work has been the keystone to the successful propagation of "Company" cotton and its being marketed for the greater part in an uncontaminated form.

The system of co-operative sale of cotton as instituted in the Tinnevelly tract is in practice a simple operation, but many difficulties which impede the progress of the work have to be encountered. Broadly speaking, the ryots of a village, or of adjoining villages, are induced to pool their seed cotton and deliver it in bulk as one consignment direct to the ginnery. When this can be done, each firm has expressed its readiness to clean out its gins previously so as to avoid accidental missing of seed in the gins. Payment is made by the firm for the lint on the day of delivery to one of the co-operators who acts as spokesman to the party. He divides on the spot amongst his fellow co-operators both the proceeds and the seed obtained in direct proportion to the quantity of seed cotton delivered by each. As is the local system, each ryot takes back his seed to the village or sells it locally to a seedsman. The cotton firms here deal in lint only. All the details of the transaction are left to the co-operators; and up to the present not a single case has been reported to me where there has been any serious difference of opinion in regard to payments made, etc.

SYSTEM OF CERTIFYING PURITY.

The progress of this co-operative effort has been accelerated by the fact that in 1916 there was on the market a fair quantity of "Company" cotton for which a premium was offered by the firms conditional to its being marketed in a pure form. An attempt was made to effect this end by promising to every grower of "Company" cotton one of the certificates already alluded to guaranteeing the purity of his produce. But a condition was imposed that a certificate would only be issued if he agreed to sell his cotton co-operatively with his neighbours.

I have previously referred to the use that is being made of these certificates. I will endeavour further to explain some of the useful purposes which they have been found to serve.

There are two certificates—A and B—issued on differently coloured strong paper. Certificate "A" bears the name of the ryot who has grown "Company" cotton, his father's name (for identification purposes), the total area under cotton cultivated by him, the area under "Company" cotton, the quantity of seed cotton previously ginned co-operatively in the current season, the quantity now ginned, the value received for his cotton, and the market rate of "Tinnies" on the date of sale. This certificate is issued to the ryot by the Circle Demonstrator who knows him personally and has inspected his standing crop. The Demonstrator signs and dates it, and the ryot, on delivery of his cotton, hands it over to the mill agent. The latter endorses it and posts it to the Deputy Director of Agriculture for registration and check purposes. Certificate "B" consolidates all the "A" certificates brought in by a number of ryots when they deliver their goods. Ryots now realize that these chits are often worth considerably more than their weight in gold, and a check on their issue has been found necessary. They are numbered consecutively and the unused balance remaining at the end of the season is destroyed.

This system of certifying the purity of cotton was originally introduced with the primary idea of meeting and checking attempts at adulterating "Company" cotton, for reports from other provinces indicated that wilful adulteration had been there a formidable bar to the progress of cotton improvement work. When a ryot is caught in an attempt to deliver under certificate adulterated "Company" cotton, that certificate is forthwith cancelled, no premium is paid for his cotton, he is blackballed for the ensuing season, and those who co-operated with him are penalized for permitting him to take such liberties.

These certificates, then, have not only fulfilled the purpose for which they were originally designed, but they have done much more. Yet the scale on which it will be possible to distribute them in the future will always be strictly limited as long as we

continue the practice of issuing them to individual ryots. The staff at the disposal of the department could never cope with the work involved by such a wholesale distribution of certificates; because it is the duty of the Demonstrator to inspect both the standing crop and the cotton marketed, and to satisfy himself before issuing the certificate that each of these is pure. This system of certifying the purity of cotton, though it has served our immediate purpose, has its weakness.

VILLAGE SEED-UNIONS.

This brings us to the question of village seed-unions. These are a recent development of the system of co-operative sale of cotton originally instituted by Mr. Sampson. I have, personally, pinned my faith all along to these seed-unions as being the keystone to the successful continuance of improvement work with "Tinnies" cotton. The necessity for organized effort to control the supply of selected seed was first seriously felt in 1915. So in 1916 six seed-unions were organized, on a tentative basis, in those villages where improvement work was most advanced. In two of these villages Agricultural Co-operative Societies already existed. Ryots who had pooled their seed cotton and had sold the lint co-operatively were induced to go one stage further and pool their seed for sale purposes. This had to be stored until the sowing season approached and then sold to the public at a premium. Here the same difficulty arose as had been previously experienced with the co-operative sale of cotton. The Tinnevelly ryot is generally a small tenant farmer and lives a hand-to-mouth existence. If he defers the sale of his produce he may increase his indebtedness, due to interest on loans, out of all proportion to the additional profits made by holding up his goods. The obvious solution to this contingency is to form co-operative societies through which the ryot may obtain advances on his stock at reasonable rates. The Co-operative Societies Department has given us much assistance in this direction. Up to the present some 12 seed-unions have been formed. Experience was gained with those first formed in 1916 to avoid pitfalls in extending the work ir 1917.

Before a seed-union is now organized in any village the way is first paved by the Circle Demonstrator for the formation of a co-operative society. The co-operative officers concerned are then invited to enquire into the feasibility of forming a co-operative credit society in that village. If this can be done a seed-union follows with a suitable constitution and by-laws. The members can, if they so desire, then borrow money from the urban bank through the co-operative society.

Seed-unions are located in such a manner as not to interfere with each other's sales. They made such profits from the sale of seed from the 1916 crop that in 1917 numerous petitions were received from village panchayats to form similar unions. "Company" seed sold at prices varying from Rs. 12 to Rs. 24 per *pothie* of 250 lb., as compared with Rs. 8 to Rs. 10 for bazaar seed.

Seed-unions now form the chief agency for distributing improved seed. Each seed-union has its own seed farm approximating in area to one-twentieth of the area grown under cotton by all the union members. Each year the department supplies the union with ample seed to cultivate this proportionate area in each seed-union village. The seed from this area is retained for their own use by the members in the following year. In the next year there is ample seed available with the union to supply to the public; but the union carries on with its own seed farm each year.

Such a system, when perfected and widely organized throughout the tract, will further be invaluable in hastening the propagation of any unit strain selection that may be found superior to those already marketed. Thus, seeing that a unit strain can be grown on an area of 20 acres after six years' propagation and preliminary testing, then assuming that it will yield twenty-fold it can—

in the 7th year be grown on	400 acres of seed farm,
in the 8th " " "	8,000 acres of union seed farm,
in the 9th " " "	160,000 acres of union lands, and
in the 10th " " "	3,200,000 acres sown from seed sold to the public from seed unions.

But the Tinnevelly tract only comprises an acreage of about 600,000. Hence allowing for an appreciable loss of seed each year for use as cattle-food, it should be possible in actual practice for any unit strain to be propagated under this system over the major portion of the tract within 10 years. This is, of course, assuming that such a unit strain would surpass anything previously placed on the market. For this purpose, it would be necessary, in theory, to organize and control not more than 75 seed-unions, each running its own seed farm averaging about 20 acres. This, I claim, is not beyond the possibilities of practical politics, but in practice numerous difficulties have to be encountered which, though they retard the rate of progress, have not been found to be insurmountable.

DEPARTMENTAL SEED FARMS.

Until the necessary seed-unions have been fully established it will be incumbent upon the department to continue its present practice of growing unit strains on contract on a much larger area than the theoretical 100 acres. Up to 1916 the average area under contract seed farms was about 500 acres. In that year special arrangements had to be made to increase the area in order to meet the "pulichai" situation. The area under ordinary contract seed farms, whereby the department purchased the seed cotton, was reduced by one half, and an area exceeding 2,000 acres was grown on contract whereby the department purchased and handled the seed only. This work, I may say, was done on the financial allotment originally made by the Government to contract for 500 acres of seed farms. Under neither system of seed farms does the Government stand to lose anything by the transaction. In spite of the premiums given by the department to contracting ryots this work is being run at a slight profit as the lint always fetches the best market-price obtainable and the seed is sold at enhanced rates for sowing. All the departmental seed grown on contract in 1917 (apart from the stock held by the seed-unions) found a ready market at 50 per cent. above the price of local seed. The demand was considerably in excess of the supply.

ADULTERATION AND "PULCHEAI" ERADICATION.

The improvement of "Tinnevellies" cotton is vitally concerned with the maintenance of purity. And as "pulichai" eradication has been given precedence for the past two seasons over all other work, it deserves at least a passing reference.

Adulteration—that insidious and cankerous disease to which so many branches of Indian trade evince a predisposition—at one time threatened not only to impede the progress of cotton improvement work in Tinnevelly, but, had it not been checked, would probably have in course of time reduced the value of "Tinnies" to that of "Bengals."

The adulterant in Tinnevelly is locally known as "pulichai," being a variety of *Gossypium neglectum.* It is a recent intruder into the Tinnevelly tract, and was first noticed in an appreciable quantity some eight years ago. The local firms, on their own initiative, attempted in concert in 1910 to stamp out this weed, but with little success. In 1915 the situation had become so serious that foreign markets complained of the tendency of "Tinnies" staple to deteriorate and they allowanced accordingly. Action was then taken by the Agricultural Department in co-operation with all the local firms, and with the revenue authorities. I am glad to be able to record that with this united effort the area under pure "pulichai" was reduced from at least 1,000 acres in 1915 to about 90 acres in 1917, with about ten times this area under "pulichai" mixtures in which the "pulichai" did not exceed 20 per cent. of the crop. The produce from the whole of the 1917 "pulichai" crop was bought by the Government at 25 per cent. below market rates for "Tinnies," which price represented its intrinsic value as "Bengals." The seed derived therefrom was publicly burnt to prevent further propagation. I have a firm belief that there will be very little, if any, pure "pulichai" cultivated this year. But there will naturally be accidental mixtures ; and the cotton firms, in view of the success that has already attended these efforts, have decided to continue their share of the work but with increased penalties for any "pulichai" received in deliveries against "Tinnevellies" contracts. Those interested in

this work will find further details in the Annual Reports of the Madras Agricultural Department for the years 1915-16 and 1916-17.

I have here made special reference to this latter branch of work because its success is intimately associated with the fact that at the crisis in 1915-16 we had at hand in one of Mr. Sampson's unit strain selections, namely, "Company 3," a cotton which could oust "pulichai" at its own game as far as ginning percentage was concerned. Whereas for spinning quality it can spin good 40's yarn as compared with 12's for "Bengals" of the *neglectum* type. We claim to have saved "Tinnies" from the fate that has befallen medium staple cottons in other parts of India, and if legislation can be introduced at this stage making it a penal offence both to grow and to gin "pulichai" cotton, then the high position held by "Tinnies" on the world's cotton markets will not only be saved but will be secured.

In regard to district work generally, I may add that no small part of the success that has been attained is to be attributed to the college-trained subordinate staff who, though new to much of the work, have far exceeded my expectations. The work demanded a degree of tact, resourcefulness, and industriousness on their part of no mean order. And as long as our Agricultural Colleges can turn out men of this calibre it will always be a pride and a pleasure to work with them.

THE CONSOLIDATION OF AGRICULTURAL HOLDINGS IN THE UNITED PROVINCES.

BY

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(Concluded from page 64, vol. XIV, pt. I.)

PART II. OUTLINE OF PROPOSED CHANGES—(*concld.*).

TYPES OF NEW VILLAGES.

IN the first place it is necessary to get a clear idea of the kind of village we wish to facilitate the growth of. In the neighbourhood of Allahabad the size of the administrative villages varies very considerably, from 200 acres or so up to about 3,000 acres. The largest villages are disliked owing to the excessive complication of the accounts, and the need of employing two or three patwaris (village accountants). On the other hand the small villages cannot support a single patwari, and one man acts for two, three or even four villages. Some administrative villages are without any inhabited site at all, the owners having migrated and the land being let or sold to inhabitants of surrounding villages who walk thence to cultivate their fields. For revenue and other administrative purposes, as well as for our purpose of consolidating holdings, it will be desirable to adopt a policy of freedom in altering, and particularly in enlarging, village boundaries, so as to produce compact villages varying from 2,000 acres up to 3,500 acres.

As such villages will often embrace four or five existing villages there will be four or five *abadis*, as may be found in some villages now. In the Punjab where rainfall is slight the choice of an *abadi* lies between several squares in an administrative *chak*; but where the monsoon rainfall (June to September) exceeds 20 inches, dwelling sites must be chosen with care; and there are not many to be found which will be dry in a wet monsoon and yet be conveniently located for water-supply and other purposes. The question of dwelling sites is much too complicated to be settled by external authority, and I think it was a pity that Mr. Moreland in his note raised the question of villagers migrating to live on their holdings, as the replies of a large proportion of the zemindars to whom the note was circulated are in opposition to the consolidation of holdings on the ground that the cultivators will refuse to leave their *abadis* and go to live on their holdings. The two questions are really entirely distinct, and should be kept so. The experience of thousands of square miles of the canal colonies shows that it is perfectly possible to have compact holdings lying at varying distances from the *abadi* in which all villagers live. A large *abadi* there becomes almost a little town, with properly planned streets and several shops, a school, and open market square.

If the cultivators ultimately find that the agricultural advantage of living on their holdings outweighs its social and other disadvantages, they will move out of their own accord, provided legal facility is given for them to obtain consent to build and also compensation for such improvement if ejected. If this protection be granted, the question may be left, I think, to settle itself. Facilities should also be arranged where desired for gradually rebuilding existing *abadis* on their present sites, so as to provide more space, wide roads, and better sanitary conditions in every way.

The arrangement of the fields, when a new allotment is made, should have reference not only to the requirements of agriculture, but also to the convenience of the revenue and land record officials, and also of the Irrigation Department in districts watered by canals. In my opinion no account should be taken of the existing field boundaries. A clean sweep should be made and redistribution

carried out on the simplest possible plan. There is no doubt that the rectangular field system, adopted in the Punjab colonies, has here, as in America, very great advantages. Whether the fields be actually made squares or rectangles all field measurements are greatly simplified, and water is saved in irrigation. A further advantage is that boundary stones cannot be shifted without detection, since the observer should always see in each direction long lines of posts at equal distances in a straight line. It does not seem to me necessary to insist on the new compact holdings being fenced in, but owners or occupiers should be at liberty to put up boundary fences, of which not less than half the thickness must be on their own land.* Fencing with mud or kachcha brick walls, or wire, should be encouraged, and hedges discouraged, except perhaps for enclosing pasture.

As regards the latter, the allotment would always provide grazing ground close to the *abadi*, and usually this would be split up into fields of about two or three acres in size so that each cultivator could have a paddock for his cattle. An alternative plan would be to have the grazing land immediately around the village split up into two or three large enclosed fields of from 20 up to 40 acres each, in each of which certain villagers would have specified grazing rights. Each house would also have a small yard of one-sixth or even only one-eighth of an acre immediately beside the house. Any stretch of waste land lying at a distance from the *abadi* could also be reserved as a pasture ground and be enclosed with a ring fence so that cattle could be left there safely enough during daylight without children posted to watch, and in some places perhaps at night. It must be remembered that one result of the rural reorganization should be to bring a school to every village, where a curriculum having a definite relation to the principal occupation would be taught; consequently the cheap labour of children would not be available for watching cattle, and they must be prevented by fences from straying into the cornfields.

* The projection over the neighbour's land should be limited to 12 inches.

Enlargement of holdings.

In the first part of this paper I have already indicated my reasons for wishing to see a considerable increase in the average size of holdings cultivated, in order that a higher standard of living may be introduced and have the opportunity of perpetuating itself. The actual size of holdings should vary considerably. It is always a false ideal to aim at uniformity where the natural conditions of utilization and of social evolution demand variety. In the first place, the size of holdings must vary according to the character and fertility of the soil and the nature of the farming for which the climate and distance from market render it suitable. In the second place, different cultivators differ very much as regards the area for which they have sufficient capital or sufficient managing ability. I have come across cases within no great distance from Allahabad where men are said to be farming as much as 200 to 300 acres, some of which they own, but most of which is rented in a multitude of small fields.* Such men must have considerable managing ability; and if they could get compact areas of 300 acres or so, they would probably be ready to learn improved methods and introduce labour-saving machinery.

It would appear that in the central parts of the Ganges plain, outside the canal irrigated area, the mode about which the holdings of cultivators wholly or mainly dependent on agriculture for their livelihood vary in size is about 8 or 9 acres.†

It is not easy to get actual statistics of areas cultivated owing to the fragmentation of the fields, and to the fact that the renting of fields in an adjoining village as a sub-tenant is a not uncommon practice. It is impossible to trace such cross-lettings except by a close analysis of the patwari's registers (*khatauni-jamabandi*) of a large group of conterminous villages, or by personal enquiries on the spot. A classification of the holdings of one village considered

* This is hearsay evidence gathered in the villages and requires confirmation by detailed inquiries. The largest figure mentioned was 600 bighas, and possibly much of it is worked on the share system.

† The *mode* is defined by statisticians as the most frequently occurring number or size in any series, or "the number of which most instances can be found."—(Bowley, *Elements of Statistics*, p. 123.)

to be very probably typical of the dry area of the Lower Doab is given in the following table :—

Sizes of groups	Number in each group	Number in half-acre groups
1 acre and under*	48	26
2 acres and over 1	41	22
3 " " " 2	21	28
4 " " " 3	17	13
5 " " " 4	11	14
6 " " " 5	9	7
7 " " " 6	2	7
8 " " " 7	8	10
9 " " " 8	4	6
10 " " " 9	1	5
11 " " " 10	3	
12 " " " 11	1	
13 " " " 12	3	
14 " " " 13	1	
15 " " " 14	0	
16 " " " 15	0	
17 " " " 16	1	
Over 17 acres :—		
38·4 acres	1	
49·5 "	1	

* The original figures are given in bighas, biswas (20=1 bigha), and biswansis (20=1 biswa) and have been converted at the rate of 32 biswas=1 acre.

These figures are plotted in the following graph, which shows that the mode is approximately one acre :—

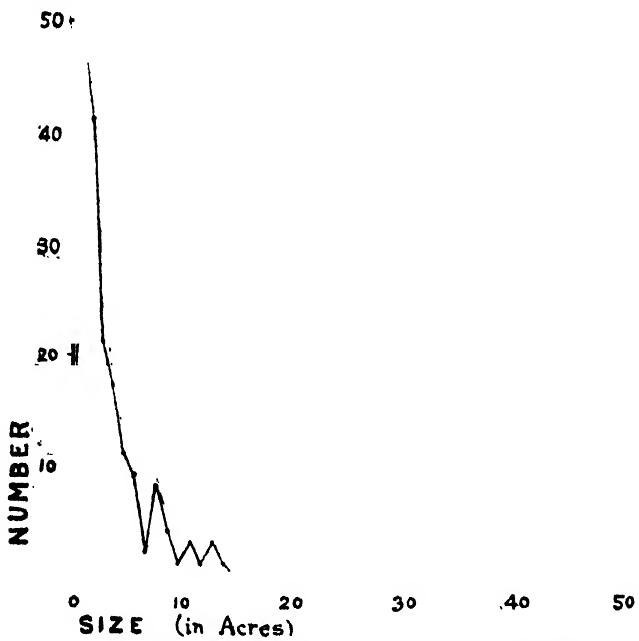


FIGURE 1. ASADULLAH-PUR ROHI VILLAGE.

The ordinates (distances measured vertically from the base line) represent the numbers of cultivation holdings (farms) in each one-acre group; and the abscissæ represent the size of the area groups in acres. The groups are defined as in the above table.

Taking all matters into consideration, it appears to me that a proper arrangement of the size of holdings, in accordance with the principles which have been outlined in the earlier part of this paper, would produce a graph of the shape shown by the continuous line in figure 2 below. The size distribution which seems now to prevail is indicated by the broken line.

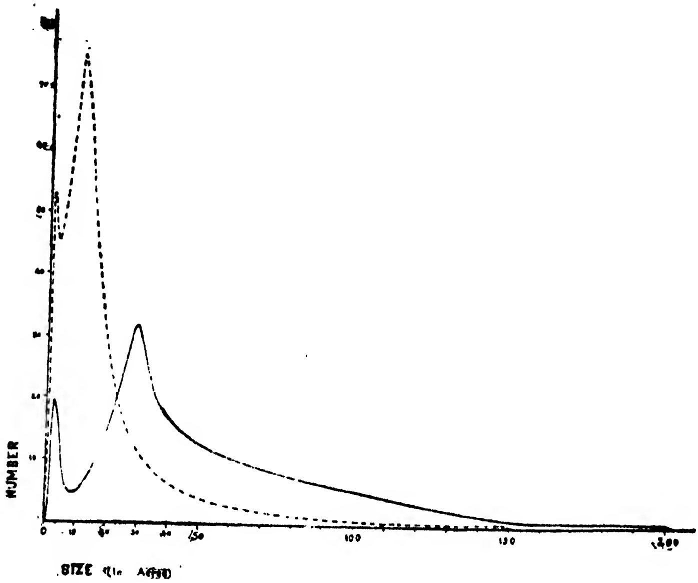


FIGURE 2. HYPOTHETICAL EXAMPLE.

The broken line is intended to illustrate the present size distribution of the existing cultivation holdings in a tahsil or district; and the continuous line represents the size distribution which is here advocated as desirable when reorganization of holdings is undertaken.

In both of the curves we see two peaks, corresponding to two distinct modes. Examining the curve representing the proposed rearrangement and enlargement of holdings we find that the first and lower mode occurs at a size of between two and three acres, whilst the other, or greater mode, occurs at about 29 or 30 acres. This curve would be interpreted to mean that there are in the group of villages represented farms of all sizes from two acres up to 200 acres, but that there is a considerable number of small holdings cultivated of about 2½ and 3 acres in size, several of four acres, and a few of six, seven, eight or nine acres. There are rather more of 10 acres, and a few more of 11 or 12 acres; and for each successive

size a greater number is to be found up to the size of 29 acres, after which the number of farms in each acre group declines pretty rapidly at first and then slowly, meaning that there are a dozen farms or so of each size up to 50 or 60 acres and a few much larger farms up to 200 acres. I am here using the word "farm" in the sense of cultivating unit. The very small ones of two up to five acres in size would be small holdings cultivated by artisans and labourers having some other occupation as their principal means of livelihood. Farms above 40 acres would mainly be cultivated by persons of special intelligence and aptitude or of considerable capacity, in many cases trained, we may hope, by one of the agricultural colleges.

The advantage of having such variety in the size of holdings is that, in the first place, it gives scope to enterprising cultivators who may be able without going to another district to move from a small to a considerably larger farm. In the second place, it tends to introduce variety in the methods of cultivation in any district. Consequently such of the larger farmers as are progressive and have sufficient capital will be a good example to those who for the time have only small holdings. Another important point is to introduce flexibility in the size of holdings so that cultivators may easily add to the area which they are farming when neighbouring land falls vacant. The rectangular field system as laid out in the Lower Bari Doab Colony would seem to lend itself excellently to this, as the squares are subdivided each into 25 fields of exactly one acre, which are numbered uniformly throughout the whole colony according to an officially established system.

Removal of surplus population.

The average size of holdings which I have indicated as desirable to be adopted as the mode is rather more than three times the mode of the existing cultivating unit. If the sole change were in the increase of the size of the holdings, it would simply mean that after the redistribution the land was to be rented to those of the previous cultivators who could best manage larger areas, and that the others would continue to reside in the villages, working on the farms as

labourers. It is an express object of the proposed policy of increasing the size of holdings thereby to create an opportunity for the introduction of better methods of cultivation; consequently so far as capital becomes available for employing labour-saving machinery there must be a displacement of hired agricultural labour. By the opening of better communication with railway stations, which should be an integral part of the scheme, there will not only be a rise in the values of farms and of the articles produced at the farms, but also increased competition of factory-made goods brought from outside to the villages, which would tend still further to kill the local home industries and crafts of the village artisans. Consequently there would be little opening for the displaced labourers in the village industries. The fact has to be faced that the introduction of labour-saving implements and machinery—even putting an efficient steel plough drawn by strong bullocks in place of the present country plough—must tend to reduce the population of the agricultural districts in India as it has done in other countries. Two very difficult questions arise: (1) how a selection is to be made of those cultivators who are to be lucky enough to get the new enlarged holdings; and (2) what is to be done with the surplus able-bodied men who would not be required as labourers, and cannot be allowed to remain destitute in the villages?

The tentative solutions of these problems which I would offer for consideration are as follows: The rentals of the new holdings must necessarily be fixed at a higher rate per acre to cover the cost of reorganization and to cover the interest on capital which, it is hoped, landlords may be induced to spend upon them, or Government to advance; and as most of the holdings would be more than three times the size of the present ones, many of the existing cultivators would be unable to face their high rentals and there would not be excessive competition for the holdings. It might, indeed, in some places be necessary to subdivide some of the larger newly made holdings in order to get tenants who could prove themselves actually able to pay the rent. By such a process of economic selection, *working from a large average size of holding down to such smaller average size as proved itself to be stable*, the best farmers, from

the cultivating and business point of view combined, would be automatically selected. The solution of the second problem of moving the surplus of competent adult labour would, I think, be a double one. Some would be offered the opportunity of taking up waste land in distant parts of India where population is badly needed. Others would be assisted to migrate to the towns where industries are growing; and they would be given every inducement to settle down there so as to form a permanent industrial population.

The enquiries that I have made show that there are waste lands, not only in the Punjab, but also very extensively in the Native States of Rajputana and Central India, such, for example, as Bikanir, Alwar, Patiala, Gwalior, Bhopal, Indore, and Rewa. In many cases irrigation is needed to make these lands available, but if there were prospects of obtaining the population, most of the Native States would be ready enough to carry out the necessary works. I think two million acres could by suitable arrangements be colonized in the Native States. The Punjab will probably fill up its own waste land. The United Provinces with their 47 million inhabitants might well contribute two or three millions for the colonization of the Rajputana and Central India States and for emigration to the Central Provinces where, I am informed, there are still many tracts of waste land on which the Central Provinces Government would be only too glad to locate settlers.* The main difficulty is the difference in type of country, the soil, rainfall and crops being different. It is for this reason that such migrations of cultivators need to be carefully organized. I may suggest that they might be managed and assisted by the Agricultural Departments of the different provinces and States working in co-operation, particular care being taken to see that newly settled colonists are located in villages (ryotwari or zemindari), at the head of which is placed a man of good character, knowing thoroughly from many years' experience the local conditions of agriculture and capable of giving instruction

* Such districts are Chanda, Balaghat, Chhattisgarh, Raipur, and Drug, and to a smaller extent Saugor. For this information I am indebted to the Hon'ble Mr. J. T. Marten, M.A., I.C.S.

therein, which should be made as much one of his official duties as the collection of revenue.

In a similar manner the emigration to growing industrial cities ought to be managed by Government in such a manner as to secure that the newcomer at least begins his industrial career under the most propitious circumstances. It is not too early even now to establish in Cawnpore and all the larger towns Government Labour Bureaus similar to those which have proved so successful in recent years in England. In regard to the immigrants from rural districts the labour bureaus should have a more comprehensive duty than merely finding employment, and should be responsible for securing decent and proper conditions of work, a fair remuneration, and sanitary and comfortable housing accommodation. It is greatly in the public interest for the promotion both of industries and agriculture that these matters pertaining to the welfare of labour in great cities should from the first be controlled in an enlightened manner. There could be no excuse for allowing the repetition in India of the scandalous social conditions which arose in the rapidly growing towns of Great Britain at the time when the agricultural revolution was squeezing the labour into the cities to be rapidly absorbed by the industrial revolution.

Replanning of roads.

A very important part of the reorganization of villages must be the complete replanning of all roads in the village and its neighbourhood. Only those roads which are already drained and metalled as first class roads would be retained in their present alignment. All other roads would be abolished and turned into ploughed fields so that the replanning of rural roads might commence with a clean sheet. The justification for this drastic measure lies in the fact that 95 per cent. of the existing roads were in existence before the railways were constructed, so that the great majority of them have no advantageous relation to the location of the railway stations. It is true that the engineers who planned the railways have often placed stations at points where important main roads, metalled or unmetalled, cross the railway; but the majority of country stations

have no main roads approaching them, and none near them, except the trunk road which usually runs parallel with the railway.

The ideal arrangement of roads would be a net-work of minor roads converging into more important roads which would themselves converge directly upon the nearest railway stations. In order to get a clear idea of the road system, we must recognize the classes of roads required, which I shall take from the smallest upwards. We have first those giving access from the village site to the various farms. These I shall term the "field" roads. As in the Punjab colonies, they would usually run along the edges of the squares and would be made from 10 to 15 feet wide, according to the number of squares to which they would give access. The metalling of these roads, if any, would be carried out mainly at the expense of the owners of the holdings served. The next class may be called "inter-village" roads. These would form a net-work of roads going from every village direct to every other adjoining village. The third class of roads we might call "station" roads, for they would run direct from the villages lying at any distance up to six miles from the railway station by the shortest route to the station, there being, however, no two roads made at an angle of less than 30° with one another. The fourth class of roads would be "trunk" roads, provided for fast motor traffic, and in order to give alternative routes for produce to reach the market towns in case of break-downs on the railway, or of freight rates proving exorbitant for short journeys.

Procedure for consolidation of holdings.

The principles which should guide the choice of a method of carrying out the reorganization of villages on the lines above described are the following. In the first place, compulsion should be avoided as far as possible, and the principle adopted that no change should be imposed upon any area unless the owners of more than one-half of that area desire the change. Should this condition be satisfied for an area which might be one village, or might embrace for special reasons two or more contiguous villages, it would seem expedient that legal power should be taken to compel the minority

to accept the redistribution of holdings under the supervision of Government. In the second place, whatever machinery might be established to carry out the redistribution, it must work in such a manner that the expense of the whole operation should be kept as low as possible, and should not in most cases exceed Rs. 15 per acre, excluding the cost of fencing the roads. In the third place, considerable elasticity should be permitted in the methods of carrying through the reorganization in different places during the first few years, as the whole undertaking would be in an experimental stage, so that different methods might be tried, and the best be ultimately selected for a permanent set of regulations. Fourthly, the possible necessity for a considerable change of the existing tenancy law in the reorganized villages must be faced. The present system actually discourages any improvements being made by landlords; and much of the benefit of the change would be lost if some alteration of the tenancy laws were not made concurrently with the reorganization of holdings. I see no difficulty in making a special tenancy law different from the general tenancy law applicable to reorganized villages in which the reorganization has been controlled or approved by Government. For the sake of completeness, I may add as a fifth principle the obvious condition that the redistribution of land must be made upon the most equitable basis possible, and that liberal compensation should be given to those, if any, who may be excluded from a former cultivating ownership.

The first step to be taken by Government would obviously be an Act enabling it to appoint certain officers with powers of receiving, taking into consideration and acting upon applications for the consolidation of holdings in any village or villages. Such a law would appoint a body of commissioners, perhaps five in number, whose duty it would be to receive petitions for consolidation. These commissioners would be jointly responsible for the carrying out of every reorganization, but they would be given the power of appointing one commissioner from among themselves to have special charge of each particular reorganization. Such commissioner would always be an experienced settlement or revenue officer. In carrying out his duties he would be assisted by two assessors who should be

persons of standing with local knowledge of the district, and who should be appointed by the commissioners from a number of suitable persons nominated by the owners and other persons interested in the proposed reorganization.

Prominent public notice having been given in the locality affected, and generally elsewhere by advertisement in the newspapers, that the proposed redistribution of holdings would be taken into consideration, the commissioner would hold a public meeting in the locality and explain, with the help of his assessors, the precise objects of the consolidation, the benefit to be expected, the classes of persons whose interests would be affected and what steps they should take to secure the benefits of the scheme and to protect themselves so far as might be necessary. Notice would then be given to all persons interested to state their claims and objections in writing, for which purpose a legal adviser might perhaps be placed at their disposal at a nominal charge.

As soon as it was made clear that a majority of the ownership of the area, whether reckoned by shares or by area of holdings, was in favour of a redistribution, the commissioners would apply to Government for sanction to proceed. For this purpose they would prepare a report which would be published in the Gazette, and Government would appoint a period of three months to hear objections. If these objections did not appear to warrant the suspension of the application, or abrogation of the proposed proceedings, Government would order the commissioners to proceed after a further period of two months. At this stage it would be open for any objector to appeal to the High Court to stay the proceedings; but this would probably involve considerable expense, and the money would be lost unless the objector could make out a very good case. The necessary period having elapsed and the High Court having issued no order to stay the proceedings, the commissioners would once more hold a public meeting in the locality and explain fully the steps by which they would proceed to effect the redistribution of holdings. They would next appoint competent surveyors and a trained valuer. They would enter into communication with the Public Works Department or the District Board as to the

replanning and the estimating for the roads. With the complete survey before them such questions as joint irrigation and drainage would be investigated; and the question of any demand existing for a new dwelling site could be raised. With all this information in their possession, the commissioners would then proceed to decide what areas should be reserved for grazing and for general purposes; and the remaining area suitable for cultivation would then be divided up for a trial allotment, and a valuation of it on this basis made. At this stage objections might be heard; but they would be largely disregarded if they conflicted with the larger interests and general purpose of the proceedings. Finally, a revised allotment might be made and a final valuation, on the basis of which the various owners would be assessed with the cost of the consolidation. The value of land required for roads other than field roads would be pooled, and deducted *pro rata* from the value of all the new allotments: but the land required to be given up for field roads to other peoples' holdings would be taken into account in deciding the individual allotments.

METHODS OF ENLARGING UNITS OF CULTIVATION.

The importance of the consolidation of holdings being accompanied by an enlargement of the average size of the unit of cultivation has already been emphasized; and it remains to consider what action the commissioners should be required to take to secure this result. It is obvious that it would not be possible to do very much to compel owners to let their land in large rather than small holdings and the control of sub-lettings would be difficult. The methods likely to be successful would be, on the one hand, to attract likely tenants away from the village and the surrounding neighbourhood, and, on the other hand, to place obstacles in the way of letting small areas.

The first would be accomplished by advertising as thoroughly as possible facilities for emigration to the towns and to districts under colonization in the manner above suggested (*see* p. 339), and by establishing agencies in the locality and for such distance around as seemed necessary in order to lessen the supply of would-be tenants

from the surrounding country. To place obstacles in the way of letting small areas, the commissioner might be required, after allotting new holdings to the owners, to proceed to define accurately the convenient farms or letting areas, having powers to insist that all the first lettings after the redistribution should be made only in accordance with these areas and without subdivision. If difficulty were experienced in letting, variation should be allowed only with the consent of the commissioner. The commissioners would fix a number of areas of from 2 to 6 acres each for letting as small holdings, and areas from 16 acres upwards for letting as farms. Power of compulsory sale of land belonging to any obstructive owner, at the new valuation rate less 10 per cent., must be given to the commissioners in case the owner were to refuse to allow his holding of, say, 10 or 12 acres to be grouped with another owner's land for letting purposes. A sufficient degree of permanence could be given to the farm areas defined by the commissioners by making it impossible for owners to recover rent by process of law for fractional parts of the officially sanctioned letting areas, unless such fractional parts were added to an adjoining whole farm and held by the same tenant. Thus farms could be amalgamated, or one be divided and its parts added to adjoining farms, but letting subdivisions of single farms would be very risky.

The adjustment of occupancy rights might prove troublesome when the new area to be let to the occupancy tenant exceeded the old area which he held with occupancy right. The commissioner might be empowered in such cases to decree a compromise whereby the area covered by occupancy right would be extended in consideration of the rent over the whole being raised to an equitable extent.

Cost of the reorganization.

It is difficult to form any estimate, but it seems probable that the cost of reorganization of areas of not less than 1,000 acres at a time would work out at between Rs. 10 and Rs. 20 per acre, excluding fencing and other physical improvements. The larger the area done in one place, the lower would be the average cost, because the

commissioner and other officers instead of paying occasional visits would reside for months together on the spot. For this reason I would advocate a procedure of placing a whole district at a time under reorganization when a sufficient number of applications had been received from it. In any district thus declared to be under reorganization, the first step would be the preparation of a general plan of trunk, station, and inter-village roads for the whole district. A reorganization commissioner would be assigned to the district for his whole time, just as a settlement officer is, and he would be assisted by different assessors in each pargana or tahsil. In any district declared to be under reorganization Government might agree to do the whole business at a flat rate of Rs. 10 per acre, whilst in isolated areas reorganized elsewhere the charge would be from Rs. 12 to Rs. 20 per acre.

In my opinion there can hardly be any question but that the consolidation of holdings would prove a very profitable operation for landowners. The market value of their lands would probably be increased by about 50 per cent. within the first five years, and still more after another five years, when skill and capital for cultivating the larger holdings would have developed and rents could be substantially raised. It would be wise for Government to undertake not to raise the land revenue *on account of the profits of the consolidation* until the period of one settlement should have elapsed; that is to say, assuming the cost to be borne by the owners. It would probably be a more popular policy, and incidentally profitable to Government, if the latter undertook to bear the whole cost of the reorganization and recouped itself by a special cess or addition to the land revenue calculated at, say, 7 or 8 per cent. per annum on the capital cost of the reorganization.

THE NECESSITY FOR EXPERIMENT.

In conclusion, I wish again to emphasize the necessity for undertaking experiments in the consolidation of holdings under favourable circumstances in all the different tracts of the country. In the United Provinces, for example, ten different areas, each consisting of one, two or three villages, might be selected, preferably

in easily accessible localities. If Government were to offer to bear the entire cost of the consolidation of the first 20,000 acres to be undertaken, without enhancement of land revenue, I am sure that there would be no lack of offers of their estates by owners. It would be necessary to make it clear that all tenancy difficulties would be smoothed over by giving the commissioners special and final powers for the purpose in these selected areas. In discussing the matter with enlightened zemindars whom I have happened to meet, the suggestion has been received with more favour than I expected, and the only serious objection raised has been the expected opposition of tenants, and the impossibility of forcibly removing the occupancy tenant from his fields even by buying him out.

In my opinion there is no reason whatever to wait and study the question further before commencing experiments. Study can best be carried on whilst actual operations are proceeding in the selected areas. The nature and extent of the difficulties cannot be discovered by any amount of arm-chair thinking beforehand. They must be discovered by experience; and similarly it is the men actually engaged in effecting the reorganization who are the most likely to be able to find solutions for the difficulties they encounter. Resourceful and trustworthy men must be selected, and they must of necessity be given very wide powers and discretion. Handled thus in a spirit of wise liberality, it is difficult to conceive that the great economic change to be thus inaugurated can be anything but beneficial in the highest degree to India and the masses of her people.

APPENDIX.

Since the foregoing paper was put into print, I have had the advantage of discussing it with Professor Patrick Geddes, and in the light of his friendly criticisms and of the discussion at Poona[1] there are a few words which it seems to me desirable to add. Professor Geddes observes, with reference to the standard of living (Vol. XIII, Pt. II, p. 223), that it is raised by three, not two, agencies: that is (1) by example, that is desire to imitate or emulate

[1] *Proceedings of the Board of Agriculture in India, Poona,* 1917, p. 26.

persons who possess the means and do actually live at a higher standard. Such example is stimulated (2) by travel and its educative effect. The remaining agency is (3) by relevant selection from the resources offered by the present educational system (though this as a whole is too urban in character and thus *townward* in its attractive and suggestive influences). It is probable also, he suggests, that the prevailing low standard of living in India was largely brought about by the necessity for concealment of property and the general depressive effect of the eighteenth century wars, a result which has been to a great extent standardized by the nineteenth century land tenancy legislation.

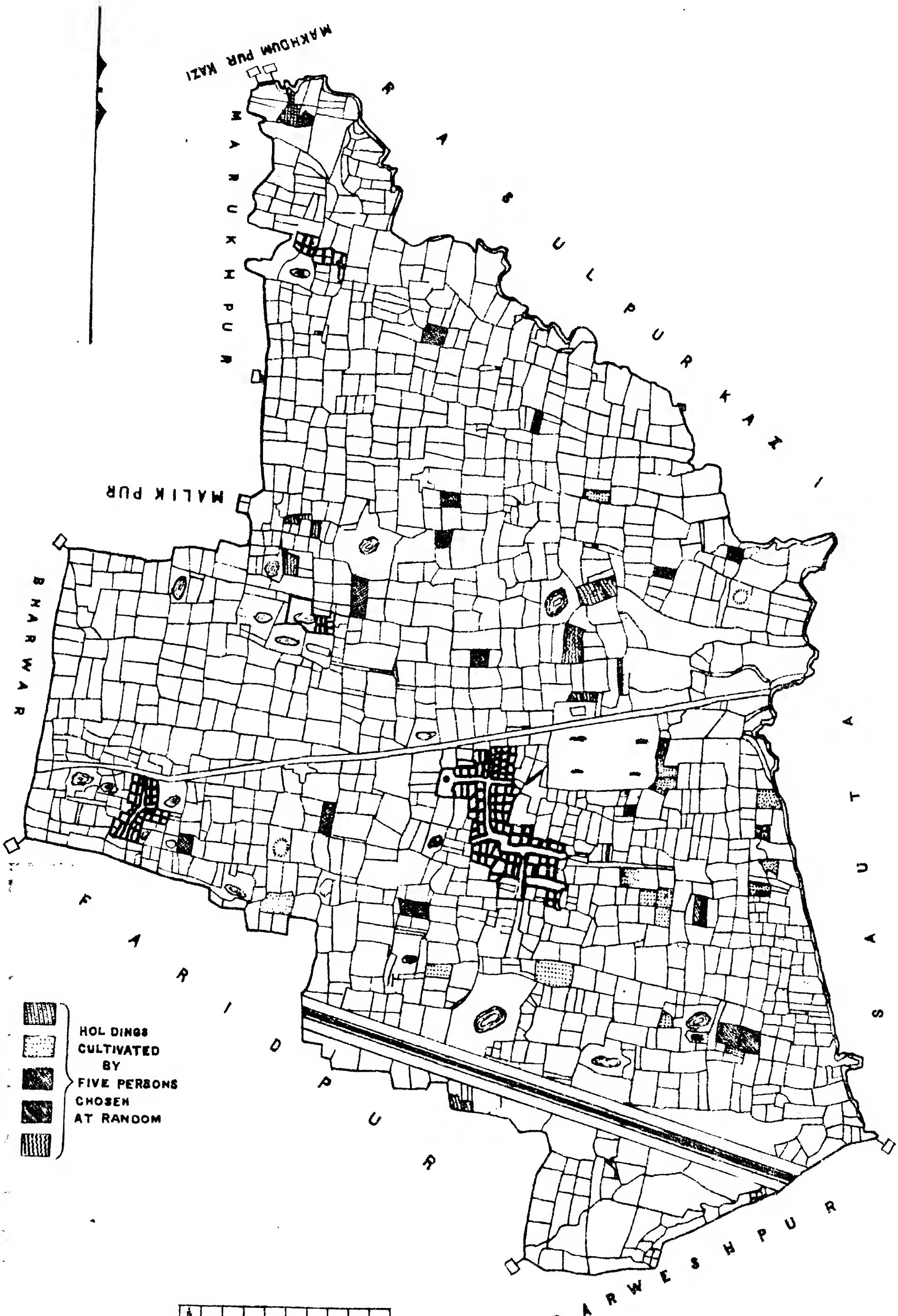
Another note by Professor Geddes refers to page 332, where I advocated that no account should be taken of existing field boundaries. He would have it that some account of them should be taken, not only when field boundaries follow the natural contours of the ground (which, of course, I intended should be followed), but also so as to avoid breaking home attachments by centring the new holding as far as possible on the family fields and trees, etc., which are most esteemed. If kept in view purely as a subsidiary aim, I agree with this also.

Another point is the shape of fields which, as Professor Geddes points out, should be long rectangles for efficiency of ploughing, and not closely approximating to squares. The holdings also, he says, should be long rectangles, as nearly as possible radiating from the village site. Again, as occupation for the surplus population, Professor Geddes would advocate the further development of forestry, fruit growing and silk culture; whilst a very considerable number of persons would be employed in the ever growing programs of public works.

One of the speakers at the Conference[1] thought that a weak point in my scheme was that the reorganization would produce a complete break with the past traditions of the village. This, however, would not be the case, as I do not propose to break up the village itself, that is the *abadi*, nor its immediate surroundings of

[1] *Ibid.*, p. 34.

VILLAGE ASADULLAH-PUR ROHI (PARGANA CHAIL)



wells, tanks, temple and sacred trees. The social centre of village life would remain unaffected by the redistribution of fields, and changes in the village buildings would only come about later by a gradual process of growth and reconstruction.

I may add that in the section on the enclosure movement in England reference should have been made to the work of Dr. Gilbert Slater, University Professor of Economics at Madras, on *The English Peasantry and the Enclosure of Common Fields*, which gives a clear statement of the methods and results of the enclosures. This book was not available to me when writing, or it would have been mentioned in the paper itself.

EXPLANATION OF VILLAGE MAP.

The lines across the bottom of the map represent the main line of the East Indian Railway; and a road crosses near the centre. There is one principal *abadi*, and there are three subordinate dwelling sites. These are shown by very heavy black lines forming a kind of cellular structure; and streets are shown in two of them. The irregular ovals represent water-tanks, *jhils*, or ponds. For the sake of illustrating the scattered nature of the holdings, the fields actually cultivated by five individual cultivators during the crop year 1913-14 have been hatched or stippled with a distinguishing design as shown in the left-hand lower corner. These five cultivators were chosen at random. It will be seen that, whilst one cultivator tilled fields scattered in twelve different places, another (the one with the top design in the key) had only two contiguous fields situated in the extreme north of the village. It is possible this last mentioned cultivator owns or rents lands in a neighbouring village.

Notes.

THE PLANET JUNIOR HAND-HOE: A COMPETITION.

THE makers would surely have been satisfied with the manner of using these handy little tools if they had seen some North-West Frontier Province workmen striving in competition the other day at Tarnab. The hoes were mostly Single-Wheel No. 17 type, and each competitor ran the hoe he customarily used in his daily labour. The tools were dismantled, their parts being placed beside the competitors ready to be adjusted when the word "go" was given. Each man was required to hoe, to cultivate, and to earth up 440 yards of drill. From start to finish the work performed was clean and determined, without undue flurry. The onlookers showed more excitement than the competitors. In altering their tools to suit the work on hand the smaller nimbler men usually gained on their more burly rivals. The cultvation was so uniformly good that the prizes were awarded chiefly for speed. It must not be thought that the competitors sped down their lines in the flowing garments that go to make the picture. (Plate VI.) The men dressed and lined up after the event, for no true Pathan will consent to be photographed if he is not worthily arrayed. They are a fine lot of men, of some character. Ten of the seventeen competitors have been employed at the Agricultural Station almost since operations began there eight years ago.

The writer hopes to contribute in a subsequent issue of this *Journal* a note regarding the employment of the Planet Junior hoes in the North-West Frontier Province.—[W. R. B.]

PLATE VI.

Planet Junior Hand-hoe competition at Tarnab.

THE following further communication from Dr. C. A. Barber, C.I.E., on the **origin of the Uba cane,** has appeared in the *International Sugar Journal* (September, 1918):—

I am much obliged to you for forwarding an advance copy of Mr. Noel Deerr's interesting statement on the origin of the Uba cane in Natal.[1] One of our greatest difficulties in India is the absence of scientific libraries dating beyond the last few years, and, with regard to sugarcane, the available literature is very limited indeed. It is gratifying that my recent letter,[2] suggesting a possible if somewhat fantastic origin for the word "Uba," has elicited a reply from one who has at command an adequate library.

There are now two theories in the field as to the origin of the Natal cane. Both of these must, I think, be examined on the basis that the Uba cane came originally from India, as it is obviously a member of the widely spread Pansahi group of indigenous canes. The first of these is that the Uba cane came direct from India to Natal. The distance is small, and Natal formerly lay upon the direct route from India to England, as it does, curiously enough, at the present moment! Two obstacles have to be overcome by those in favour of this theory. The first is the *name,* which is not given in India to any of the Pansahi group, nor indeed to any other cane that I have met. I do not of course lay any stress on the suggested connexion with the two Burmese words "U-ba," referred to in my letter. The second is that there is no direct evidence of the Uba cane having been brought from India. Unless the cane came from Burma, where I regard it as an introduction from Bihar, and where much better canes abound, it is difficult to understand how else it could have reached Natal. The Pansahi class is not characteristic of Bengal, which has, and has had for several centuries, a number of thicker and better canes. I regard it as unlikely that such a cane as Uba would have been obtainable, or that, if obtainable, it would have been considered at all a desirable one, to introduce into a foreign country. With the exception of Lower Burma, there

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[1] Reprinted in the *Agric. Journ. of India,* vol. XIII, pt. IV.
[2] Reprinted in the *Agric. Journ. of India,* vol. XIII, pt. III.

is a lack of connexion between India and Natal as regards this cane.

The second theory is that the Uba cane came from Brazil, and Mr. Noel Deerr gives chapter and verse for this introduction to Mauritius in 1869. But as Mr. Deerr points out, this opens up an interesting speculation. In studying the characters of the indigenous Indian canes and those of the tropics, I have all along been trying to find the line along which the latter might have been evolved from the former. It has always been somewhat loosely considered possible that, during the many hundreds of years of tropical cultivation, the Indian canes may have been so altered in their growth that they assumed the present form of the thicker canes. But if the cane which Alexander took from India over 2,000 years ago has so little changed in its character that it can unhesitatingly be placed in its own class of Indian canes, this idea receives a severe check. What chance was there that Alexander came into closer contact with the Pansahi group than the Natal planters?

The canes of the Punjab are of two classes. Near big towns, we have thick tropical canes which are used for chewing and are heavily manured and cut before they are ripe. These grow well at Amritsar, where I have met with and studied two kinds. Thick canes are again found in the neighbourhood of Peshawar, where frost is absent and some 30,000 acres are grown on a crop scale for making *gur*. But all the evidence is that these canes have been introduced comparatively recently into this part of India, and I do not think it at all likely that, when Alexander came to India, there were any but the thin frost-resistant forms which are still growing in the fields. These are described by me in a Memoir of the Indian Agricultural Department, and it will be readily conceded that they are among the thinnest and most primitive canes in the world. But among them is one of the Pansahi class, described as non-resistant to frost, occasionally being totally wiped out, and then, for several years, being gradually re-introduced, from the East where the true zone of the Pansahi group lies, along the foot of the Himalayas as far as Bihar. This cane is called *Kahu*. It is

grown in the neighbourhood of the Beas river and is valued in that it is less fibrous and more juicy than the other more grass-like canes of the province. Now, Alexander in his Indian irruption came as far as the Hyphasis river, the ancient name for the Beas. Naturally he would take the best cane he could meet with, and the point of contact is perfect, if the local canes growing then were the same as those now found in the province.

Can other links in the chain of evidence be found? Is it possible that in corners of Spain there may still be remnants of the cane that Alexander took? Can the local reed-like cane of Brazil be still found in the primitive Indian settlements of the country? And if so, is it of the Pansahi class? Is there any other source of the Brazil canes, in Japan for instance?

The importance of these questions on the origin of the cultivated sugarcane cannot be exaggerated. There are, I believe, many references to the introduction to the West of canes "from Malabar," and these were thick tropical canes. This has led to an idea that India itself might contain the links of the chain of development between the indigenous canes of the country and the thick canes of the tropics. But, if this is so, how can we explain the fact that in South India there are at least four indigenous varieties, *Naanal* in the south of Madras, *Hotte Cheni* and *Ganda Cheni* in Mysore, and *Hullu* in Canara? These are easily distinguishable from the thick, introduced canes, and there is no suggestion of their not having been in the country for many generations. They are thicker than the Punjab canes, although belonging to the same class, as has been clearly shown in a recent Memoir prepared by me and about to issue from the press. In fact, to sum up the discussion, it seems to me that Mr. Noel Deerr's letter suggests much more strongly than has ever been done before, that the thick canes and the indigenous Indian canes have had an entirely different origin, the latter having arisen from one or more wild forms similar to those now growing in India, and the former from another species of Saccharum, probably now extinct in its wild form, and native to the islands of the Malay Archipelago, or possibly Cochin China, as suggested in de Candolle's "Origin of Cultivated Plants."

SUGAR FACTORIES IN INDIA.

A PRESS COMMUNIQUE, dated 3rd December, 1918, issued by the Department of Statistics, India, says:—

Enquiries were recently undertaken by the Department of Statistics, India, regarding the sugar producing capacity of the sugar factories in India. Of the forty-six factories to which enquiries were addressed, returns from thirty were received. Of the remaining sixteen, six did not give any reply, six others were either closed or were not in working order, business was not started by two, one was opened only in August, and one was omitted as it produced only molasses.

The results of the census show that the thirty factories turn out per day of twenty-two hours 4,900 maunds (of 82·3 lb. each) of sugar from cane (first sugars), 2,100 maunds from cane (second sugars), 7,200 maunds from raw sugar, 3,600 maunds of molasses from cane, and 3,700 maunds from raw sugar, employing on an average 8,600 persons daily. The maximum amount of sugar that can be produced by these factories is, according to the returns furnished, 14,500 maunds (or 533 tons) per day. The details for the provinces are given in the statement below:—

Province	Number of factories	Sugar produced from			Molasses produced from		Maximum production		Average number of persons employed daily
		Cane—first sugars	Cane—second sugars	Raw sugar	Cane	Raw sugar	Sugar	Molasses	
		Mds.	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.	
Bihar and Orissa ..	13	2,853	758	1,262	1,554	1,156	4,829	2,606	3,008
United Provinces ...	9	1,015*	802	1,737	1,142†	1,592†	3,831	2,936†	2,053
Madras ...	5	975	507	1,411	861	828	2,246	1,233	2,676
Bengal and Punjab ..	3	32	17	2,823	22	139	3,550	324	850
Total	30	4,875	2,084	7,233	3,579	3,715	14,456	7,099	8,587

* Includes production of second sugars in one factory, separate figures not being available. The high proportion of second sugars in the United Provinces is due to the fact that ration sugar of about 98 degrees polarization, manufactured for the Army Department, has been classed under "second sugars."

† Excluding production of molasses in one factory, information not being available.

The department is greatly obliged to manufacturers throughout India for their invaluable assistance throughout this enquiry. The suggestion which has been made to hold the enquiry periodically as a guide to the progress of the industry is under consideration.

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THE INHERITANCE OF MILK AND FAT PRODUCTION IN CATTLE.

At the Maine Agricultural Experiment Station Mr. John W. Gowen has made a genetic study of the first-generation crosses of prominent dairy breeds of cattle and beef-bred Aberdeen-Angus. This work, the results of which are published in the *Journal of Agricultural Research* (Vol. XV, October 1918, pp. 1-57, 6 plates), was undertaken as a link in the chain of evidence necessary to the final solution of the problems which are connected with the inheritance of milk production and butter-fat production. A cross-bred herd is being formed at the experiment station so as to provide as much material as possible for the analysis of the laws of heredity concerned with the productivity referred to, and this herd has now gone into its second generation.

An indication may be given of some of the important results already reached by Mr. Gowen :—

(1) Black body colour is dominant to the other colour in the first generation. In the second generation an orange-coated bull and a dark Jersey dun-coated heifer were segregated out.

(2) White marking of the body, taken as a whole, appears as a dominant. Study of individual white areas, however, indicates that this is due to white in the inguinal region only, for this alone appears as such a dominant. White spots on the face, neck, shoulders, rump, flanks, and legs are generally suppressed in the offspring when the white-spotted individuals are mated to solid colour.

(3) Pigmented muzzle is dominant to one not so pigmented.

(4) A pigmented tongue is dominant to a non-pigmented one—a confirmation of a previous result.

(5) A black switch appears to cause the suppression of the other switch colours in the offspring.

(6) Some exceptions were found to the previously accepted hypothesis of simple dominance of polledness over the horned condition, and it is suggested that a hormone secreted by the testes may have some influence on the presence or absence of horns. Should this prove true, it would establish an interesting parallel between cattle and sheep, for in the latter a sex hormone is known to affect the development of the horns.

(7) The qualities of beef production are shown to be divisible into four general regions of the body : head, forequarters, barrel, and hindquarters. When either parent is of Aberdeen-Angus breed the offspring show the characteristic type of head and heavy, deep-fleshed forequarters. The body and hindquarters appear intermediate, but resemble most the dairy parents. From his results so far the author concludes that for the improvement of the beef qualities of dairy breeds the first generation crosses show an increased value of the beef qualities in the forequarters without materially influencing the hindquarters.

(8) A few data are supplied as to the production of milk and butter-fat by some of the cross-breds. The results indicate that milk and fat production behave separately in inheritance. High milk production is dominant to low, but, unfortunately, a high fat percentage in the milk is recessive to a low fat percentage. The author supplies a useful bibliography and numerous illustrations.—[*Nature*, dated January 30th, 1919.]

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NATIONAL INSTITUTE OF AGRICULTURAL BOTANY.

At a meeting at the Cannon Street Hotel, on 15th July, 1918, under the auspices of the Agricultural Seed Trades Association of the United Kingdom, Mr. Lawrence Weaver, C.B.E., Controller of Supplies, Food Production Department, announced that Sir Robert McAlpine and Sons had contributed to the endowment of the National Institute of Agricultural Botany a sum of £10,000 in addition to £1,000 a year for five years, and five other gentlemen had given £1,000 each, while the Association of Corn and Agricultural Merchants and the Millers Association had also opened subscription

lists for their members. At the close of the meeting it was announced that the Seed Trade had contributed over £10,500 which has since increased to £13,000. Mr. Weaver explained that none of the money subscribed would be used for building the Official Seed Testing Station. This would form part of the Institute, but its cost would be provided by the Board of Agriculture. The Trust Fund, so far, amounts to about £36,000, and it is hoped will reach £50,000.—[*Journal of the Board of Agriculture*, August 1918, p. 518.]

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THE BRITISH DYE INDUSTRY.

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It is satisfactory to find that the Port Ellesmere Indigo Factory has been in full work for some time, and that land has been secured for considerable extensions of the works in the near future.—[*Nature*, dated January 16th, 1919, p. 388.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

WOODHOUSE-SOUTHERN MEMORIAL FUND.

The following donations have been received in answer to my appeal in the January Number, for funds to establish Memorial Prizes to perpetuate the memory of these officers.

As I may be going on leave shortly, will future subscribers kindly send their donations direct to the National Bank of India, Limited, Calcutta ? Cheques should be crossed "Woodhouse-Southern Memorial Account."

J. Mackenna.

1*st March*, 1919.

Donations received up to 28th February, 1919.

	Rs.
The Hon'ble Sir Claude Hill, I.C.S.	30
The Hon'ble Mr. R. A. Mant, I.C.S.	30
J. Mackenna, Esq., I.C.S.	100
Dr. C. A. Barber	100
G. A. D. Stuart, Esq., I.C.S.	75
F. R. Parnell, Esq.	10
The Hon'ble Mr. H. R. C. Hailey, I.C.S.	15
Botanists, U. P.	30
W. Robertson Brown, Esq.	15
G. S. Henderson, Esq.	50
C. P. Mayadas, Esq.	50
Anonymous (S)	30
Carried forward Rs. ..	535

		Brought forward	Rs.	535
H. D. Watson, Esq., I.C.S. (S)	..	..	..	25
Dr. E. J. Butler	..	..	..	50
A. Howard, Esq.	..	..	..	25
Mrs. Gabrielle L. C. Howard	..	..	..	25
Dr. W. H. Harrison ..	..	..	..	30
C. M. Hutchinson, Esq. ..	..	..	..	30
T. Bainbrigge Fletcher, Esq. ..	..	..	..	25
Dr. F. J. F. Shaw ..	..	..	..	25
Wynne Sayer, Esq. ..	..	..	..	50
M. Afzal Hussain, Esq. ..	..	..	..	25
W. A. Davis, Esq. ..	..	..	..	20
H. E. Annett, Esq. ..	..	..	..	15
C. Somers Taylor, Esq. ..	..	..	..	50
A. Carruth, Esq.	..	..	..	100
		Total Rs.	..	1,030

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* *

His Excellency the Viceroy, accompanied by the Hon. Sir Claude Hill, paid a visit to Pusa from the 4th to 6th January, 1919. His Excellency was shown over the various sections of the Institute and evinced much interest in all that he saw.

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* *

The New Year Honours' List contains the following names which will be of interest to the Agricultural Department :—

K.C.I.E. The Hon'ble Mr. N. D. Beatson-Bell, C.S.I., C.I.E., I.C.S., Chief Commissioner, Assam (sometime Director of Land Records and Agriculture, Eastern Bengal and Assam).

C.B.E. Mr. E. A. Molony, I.C.S., Commissioner, Agra Division, United Provinces (sometime Offg. Director of Land Records and Agriculture, United Provinces).

M.B.E. Mr. B. C. Burt, B.Sc., Deputy Director of Agriculture, United Provinces.

Khan Bahadur. Mr. Judah Hyam, F.Z.S., Veterinary Overseer, Agricultural Research Institute, Pusa.

Rao Saheb. M. R. Ry. M. R. Ramaswami Sivan, Avargal, B.A., Senior Assistant to the Government Agricultural Chemist, Coimbatore, in the Madras Presidency.

Rao Saheb. MR. KASANJI D. NAIK, M.A., Assistant Superintendent, Office of the Agricultural Adviser to the Government of India, Pusa.

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LIEUTENANT-COLONEL G. K. WALKER, C.I.E., F.R.C.V.S., Indian Defence Force, has been appointed to be an Officer of the Most Exalted Order of the British Empire for services brought to notice in His Excellency the Commander-in-Chief's Despatch, dated the 20th August, 1918.

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DR. E. J. BUTLER, M.B., F.L.S., Imperial Mycologist, has been appointed Joint Director of the Agricultural Research Institute, Pusa, in addition to his present duties, with effect from the 20th January, 1919, and until further orders. The post of Assistant to the Agricultural Adviser is placed in abeyance.

***

MR. G. S. HENDERSON, N.D.A., N.D.D., has been confirmed in the appointment of Imperial Agriculturist with effect from the 1st March, 1918.

***

MR. WYNNE SAYER, B.A., whose appointment as Assistant to the Agricultural Adviser to the Government of India has been temporarily placed in abeyance, is, with effect from the 20th January, 1919, appointed to officiate as Imperial Agriculturist, during the absence, on deputation under the Munitions Board, of Mr. G. S. Henderson, or until further orders.

***

MR. M. AFZAL HUSSAIN, M.SC., has been appointed Supernumerary Entomologist, Pusa.

***

DR. W. BURNS, Economic Botanist to Government, Bombay, has been allowed, with effect from the 15th January, 1919, combined leave for six months.

Mr. S. L. Ajrekar, B.A., Assistant Professor of Mycology at the Agricultural College, Poona, has been appointed to act as Economic Botanist to the Government of Bombay, *vice* Dr. W. Burns, granted leave.

***

Mr. M. H. Sowerby, M.R.C.V.S., Assistant Principal, Bombay Veterinary College, is granted furlough for three months with effect from 1st August, 1919.

Mr. N. D. Dhakmarvala, First Professor, will officiate in place of Mr. Sowerby, pending further orders.

***

His Majesty's Secretary of State for India has appointed Mr. P. H. Rama Reddi as Deputy Director of Agriculture, Madras, on probation for three years. He has been posted to the Agricultural College and Research Institute, Coimbatore, for training.

***

M. R. Ry. J. Chelvaranga Raju Garu, Deputy Director of Agriculture, IV Circle, Madras Presidency, is granted privilege leave for one month.

M. R. Ry. C. Narayana Ayyar, Avargal, Assistant Director of Agriculture, on relief from the VI Circle, will be in charge of the IV Circle.

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Mr. F. Smith, B.Sc., F.H.A.S., M.R.A.S.E., Deputy Director of Agriculture, Western Circle, Bengal, has been allowed combined leave for 14 months with effect from the 15th January, 1919.

Babu Rajeswar Das Gupta, Superintendent of Agriculture, is appointed to act as Deputy Director of Agriculture, Western Circle, *vice* Mr. F. Smith.

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Mr. A. C. Dobbs, B.A., Deputy Director of Agriculture, Chota Nagpur Circle, has been appointed to act, in addition to his own

duties, as Director of Agriculture, Bihar and Orissa, during the absence, on deputation, of Mr. G. Milne, I.C.S., or until further orders.

***

MR. J. ROBINSON, N.D.D., Offg. Deputy Director of Agriculture, Patna Circle, Bihar and Orissa, was granted privilege leave for one month and fifteen days with effect from the 2nd January, 1919.

***

MR. H. L. DATTA, B.A., M.Sc.A., Assistant Professor of Entomology, Sabour Agricultural College, has been appointed to act as Economic Botanist, Bihar and Orissa, *vice* Mr. E. J. Woodhouse, deceased, during the absence, on deputation, of Mr. S. K. Basu, M.A., appointed to act as Deputy Director of Agriculture, Orissa Circle, or until further orders.

***

MR. H. M. LEAKE, M.A., F.L.S., Offg. Principal, Agricultural College, Cawnpore, has been confirmed in that appointment, *vice* Mr. A. W. Fremantle, retired.

***

MR. W. ROBERTS, B.Sc., Principal and Professor of Agriculture, Punjab Agricultural College, Lyallpur, has been granted combined leave for three months with effect from the 8th January, 1919.

Mr. B. H. Wilsdon, B.A., Agricultural Chemist, Punjab, officiates as Principal.

Mr. O. T. Faulkner, B.A., Deputy Director of Agriculture, Punjab, has been appointed to officiate as Professor of Agriculture.

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MALIK SULTAN ALI, who has been appointed by His Majesty's Secretary of State for India to the Indian Agricultural Service in the Punjab, has assumed charge as a Supernumerary Deputy Director of Agriculture, and has been posted to Lyallpur for training.

Mr. G. Taylor, M.R.C.V.S., on reversion from Bombay to the Civil Veterinary Department, Punjab, resumed charge of his duties as Superintendent, South Punjab, with effect from the 8th January, 1919.

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Maung Ba Kyaw, temporary Engineer in the P. W. D., Burma, whose services have been transferred to the local Agricultural Department, has been appointed as an Agricultural Engineer in the department with headquarters at Mandalay.

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Mr. F. J. Plymen, A.C.G.I., Indian Agricultural Service, has been nominated a member of the Legislative Council of the Chief Commissioner of the Central Provinces in place of the Hon'ble Mr. Hughes-Hallett, resigned.

***

On being released from military duty, Mr. A. G. Birt, B.Sc., is appointed Deputy Director of Agriculture, Assam.

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Mr. W. Harris, M.R.C.V.S., Superintendent, Civil Veterinary Department, Assam, has been granted combined leave for six months from 15th April, 1919.

Reviews.

Plant Products and Chemical Fertilizers.—By S. HOARE COLLINS, M.Sc., F.I.C. (London: Baillière, Tindall & Cox.) Price 7*s.* 6*d.*

THIS book forms one of a series of volumes now being issued under the editorship of Dr. S. Rideal, which aims at giving a comprehensive survey of the chemical industries. In the general preface to the series, Dr. Rideal states that in these monographs "an attempt will be made to get away from the orthodox text-book, manner, not only to make the treatment original but also to appeal to the very large class of readers already possessing good text-books of which there are quite sufficient. The books should also be found useful by men of affairs having no special technical knowledge, but who may require from time to time to refer to technical matters in a book of moderate compass, with references to the large standard works for fuller details on special points if required."

Within the limits imposed by this scheme Mr. Collins has performed his task well. To the special student of agriculture it is possible that the treatment of some of the subjects will appear rather sketchy, but to the general reader or graduate of a science course the book will probably appeal as a useful introduction to a large subject.

The first 60 pages (Part I) deal in general terms with the principal classes of fertilizers. In Part II (40 pages), soils, soil improvers and soil reclamation are discussed. In Part III (78 pages), a very general account is given of the principal plant products—carbohydrates produced by crops, oils, nitrogen compounds of plants and

miscellaneous plant products, such as tea, coffee, rubber, indigo. In Part IV, the author deals with the production of meat, manuring for meat, the nature of the cattle foods, their calorific value and dairy products.

At the end of each section a list of text-books and recent papers dealing with the particular subjects of that section is appended, which should serve as a useful guide to the reader who requires more detailed information.—[W. A. D.]

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The Chemistry of Farm Practice.—By T. E. KEITT. (New York: J. Wiley & Sons, Ltd., Inc.; London: Chapman & Hall, Ltd.) Price 6*s.* *net.*

THIS book is intended by its author to furnish the fundamentals of chemistry required for intelligent agriculture, and to apply this knowledge to the art of agriculture and its problems. In addition to the commoner problems associated with soils and fertilizers and feeds, it attempts to include subjects such as sanitary water, boiled water, and insecticides which, in the words of the preface, "are subjects in which not only the farmer but the suburban resident is interested." It will be understood by this that the subject matter is diffuse in character, and a large number of subjects are touched on in the 243 pages which the book contains.

The early chapters are devoted to general chemistry. In these, such terms astatomic weight, valency, compounds and mixtures are simply explained, rules regarding the representation of chemical compounds by formulæ are given, and the processes of oxidation and reduction are outlined in popular fashion. Chapter IV deals with the preparation and properties of the elements necessary for plant growth. Attention is given to the importance of nitrogen and its fixation by bacterial flora in the soil, and by those living in symbiosis with legumes, but little emphasis appears to be given to the use of nitrogen by plant in combined forms.

In the chapter devoted to water, the requirements of the suburban reader get more attention and a fair amount of space is taken up by the solvent properties of water and its suitability for drinking.

The characteristics which may make it more or less suitable for irrigation have been passed over.

In dealing with air in the soil an attempt has been made to deal with the diffusion of gases in the soil. This appears somewhat too advanced for a book of this type, and is too shortly dealt with to be of much use to the reader.

The same criticism might be made with reference to the section on the leaching of plant food from plants in the next chapter. In both cases the space taken might have been better given to a slightly fuller treatment of the more elementary aspects of the subjects covered.

The chapters on soil formation, fertility, manures and fertilizers and their application give the reader useful information. Though in comparing the use of green crops as direct manure and after feeding in the form of excreta, slightly undue importance is given to the loss of carbon in the latter's formation and on the resulting value. While the relation between the manurial constituents of the food consumed and those of the excreta voided might have been more clearly impressed. Terms like denitrification and fixation of nitrogen have been used in a somewhat loose sense. It is also doubtful as to how far the public for whom the book is intended would be in a position to apply the information detailed in Chapter XV, which deals principally with laboratory methods of estimation. The space devoted to feeding and dairying is not large. The former might have been improved by more emphasis on the importance of digestibility and by some reference to the energy value of the food.

The chapters given to insecticides and fungicides and to paints, whitewashes and concrete are instructive. The illustrations are good. It is doubtful whether the book as a whole would prove of much value to a student at an agricultural college in India. In the case of a short course student it might be at times referred to as giving a simple chemical explanation of a portion of an agricultural lecture, or as something to read to emphasize the subject matter taught in a lecture. To a student in the upper classes, who is studying agricultural chemistry, it is of little or no use, as generally the treatment is

too superficial in character. On the other hand, it is beyond the Indian farmer and high-school boy of the present day. [R. G. A.]

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WE have received from Mr. A. B. Modak, the enterprising head of the Union Agency of Bombay, a firm dealing in seed, concentrated manures, and other agricultural requisites, an illustrated brochure giving an account of the present condition and future prospects of potato cultivation in the Bombay Deccan from the pen of Dr. Harold H. Mann, Principal of the Poona Agricultural College, and also a description of the **Potato Works** started by the firm. These Works have been **started by the Union Agency** with the help of Government and in co-operation with the Agricultural Department, to put on the market good acclimatized potato seed, and to carry on research with a view to introduce improvements in the cultivation and manuring of this important crop. In spite of the well-known profitableness of this crop in the Bombay Deccan, it is at present restricted to only 8,000 acres. This has been due mainly to the difficulty in maintaining the quality of the seed potatoes. It is necessary to import annually large quantities of seed from Italy, while the prevalence of certain diseases of the growing plant and of the tubers in storage and the smallness of yield owing to the use of inferior seed and faulty methods of cultivation have tended to restrict the area under this crop. The problems involved therefore require to be dealt with from the mycological, entomological, chemical, and agricultural sides simultaneously, and though some work had been done departmentally in the past, it was not possible for the department with its small staff spread over a large area to concentrate on a single problem in a single locality. It is, therefore, gratifying that a commercial company has come forward to co-operate with the department, so that by pooling their staff and funds such concentration can be brought about. During the short period of its existence the Works have already negotiated over 800 tons of seed potatoes, and extracts from letters of those who have tried the seed, which are published in the brochure, show very encouraging results. The agent used for fumigation is petrol vapour, whereby

liability to fungal or insect disease, both in the field and in storage, is eliminated to a great extent. The Works are also designing improvements in the implements used in potato cultivation, and are experimenting with various manure mixtures mainly with the assistance of Dr. Mann who has succeeded in obtaining some very good results. The Works are conducted by a staff of agricultural graduates, and it is encouraging to find that students trained in our Agricultural Colleges do not look merely to service under Government, but have now begun to put to practical use what scientific instruction they have received.—[EDITOR.]

* *

Household Dairying (in Marathi).—By B. K. Ghare, L.Ag., Lecturer, Agricultural College, Cawnpore. Pages 4+48. (Poona : Arya Bhusan Press.)

THIS is the third of the series of books on milk and dairying in its different aspects, so far published by the author. The four chapters into which this little book is divided deal with (1) milk, (2) dairying, (3) care of animals, and (4) the feeding of infants, and under each head broad facts of the subject are carefully selected and given the prominence they deserve.

It also summarizes in a very concise manner the crude and objectionable Indian methods of dealing with milk from the time it is drawn to the time it is consumed in an Indian household. The author suggests some adoptable Western methods for the improvement of the existing dairy practices in the country and brings forcibly and clearly to the notice of the reader the importance of thorough cleanliness in the handling of milk and its products, of the milk utensils as well as the milk room, and the preservation of milk in all its purity under varying conditions.

We have, however, found some slight inaccuracies in the book. For example, it is not correct to say that colostrum milk is yielded by the cow after parturition only for a couple of days, and that the buffalo is an aquatic animal from its fondness for water. Such loose expressions should be avoided when bringing out another

edition of the pamphlet. We do not think the advice given about taking cattle to the river daily for a wash and swim is sound and such as can be safely recommended.

Our opinion of this little book is, however, very favourable, and it is to be hoped that it will help in dispelling the general ignorance about milk sanitation which seems to prevail. It will be studied with profit by all interested in the sanitary production and handling of milk.—[J. H.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

1. Cotton, by G. Bidgwood. Pp. viii+294. ("Staple Trades and Industries.") (London: Constable & Co., Ltd.) Price 6*s*. 6*d*. net.

2. Tea, by D. Hunter. ("Staple Trades and Industries.") (London: Constable & Co., Ltd.)

3. A System of Physical Chemistry, by Prof. W. C. MacLewis. Vols. II & III. (London: Longmans & Co.)

4. Methods of measuring Temperature, by Dr. Eyer Griffiths. With an Introduction by Principal E. H. Griffiths. Pp. xi+176. (London: Charles Griffin & Co.) Price 8*s*. 6*d*. net.

5. Winter Botany, by Prof. W. Trelease. Pp. xxxii+394. (Urbana: Prof. W. Trelease.) Price 2.50 dollars.

6. A History of Chemistry, by Prof. F. J. Moore. Pp. xiv+292. (New York: McGraw-Hill Book Co., Ltd.) Price 12*s*. 6*d*. net.

7. The Quantitative Method in Biology, by Prof. J. Macleod. (Messrs. Longmans & Co.)

8. School Entomology: An Elementary Text-book of Entomology for Secondary Schools and Agricultural Short Courses, by E. Dwight Sanderson and L. M. Peairs. Pp. vii+356. (New York: J. Wiley & Sons, Inc.; London: Chapman & Hall.) Price 7*s*. net.

9. Modern Fruit-Growing, by W. P. Seabrook. Pp. xliii+172. (London: The Lockwood Press.) Price 4*s*. 6*d*. net.

10. Introduction to Inorganic Chemistry, by Prof. A. Smith. Third Edition. Pp. xiv+925. (London G. Bell & Sons, Ltd.) Price 8*s*. 6*d*. net.

11. Experimental Inorganic Chemistry, by Prof. A. Smith. Sixth Edition. Pp. vii+171. (London: G. Bell & Sons, Ltd.) Price 3*s*. 6*d*. net.

12. Laboratory Outline of College Chemistry, by Prof. A. Smith, Pp. v+206. (London: G. Bell & Sons, Ltd.) Price 3*s*. net.

13. All alive O? A Vade Mecum for Breeders and Feeders of Horses, etc., by J. G. Lyall. Pp. 86. (Lincoln: Lyall & Sons.) Price 2*s*. 6d.

14. A Junior Course of Practical Zoology, by the late Prof. A. Milnes Marshall and Dr. C. H. Hurst. Eighth Edition, Revised by Prof. F. W. Gamble. Pp. xxxvi+515. (London: J. Murray.) Price 12*s*. net.

15. Plant Physiology, by Prof. V. I. Palladin. Authorised English Edition. Edited by Prof. B. E. Livingston. Pp. xxv+320. (Philadelphia: P. Blakiston's Son & Co.) Price 3 dollars net.

16. Stoichiometry, by Prof. S. Young. Second Edition. Pp. xiv+363. (London: Longmans, Green & Co.) Price 12*s*. 6*d*. net.

17. A Manual of Elementary Zoology, by L. A. Borrdaile. Second Edition. Pp. xiv.+616. (London: H. Frowde and Hodder and Stoughton). Price 16*s*. net.

18. Forced Movements, Tropisms, and Animal Conduct, by Dr. J. Loeb. (Monographs on Experimental Biology.) Pp. 209. (Philadelphia and London: J. B. Lippincott Co.) Price 10*s*. 6*d*. net.

19. Catalysis in Industrial Chemistry, by Prof. G. G. Henderson, Pp. ix+202. (London, Longmans, green & Co.) Price, 9*s*. net.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. The Rice Worm (*Tylenchus angustus*) and its Control, by E. J. Butler, M.B., F.L.S. (Botanical Series, Vol. X, No. 1.) Price, Rs. 1-4 or 2.
2. Cholam (*A. Sorghum*) as a Substitute for Barley in Malting Operations, by B. Viswanath, T. Lakshmana Row, B.A., and P.A. Raghunathaswami Ayyangar, Dip Ag. (Chemical Series, Vol. V, No. 4.) Price, As. 12 or 1*s*.

Bulletins.

1. Are Camels susceptible to Black Quarter, Hæmorrhagic Septicæmia, and Rinderpest ? by H.E. Cross, M.R.C.V.S., D.V.H., A. Sc. (Bulletin No. 80.) Price, As. 4 or 5*d*.
2. Progress of the Sugarcane Industry in India during the years 1916 and 1917. Being Notes submitted to the Meeting of the Board of Agriculture in India, Poona, 1917. Edited, with an Introduction, by C. A., Barber, C.I.E., Sc. D., F.L.S. (Bulletin No. 83.) Price, As. 5 or 6*d*.
3. Soil Drainage, by R. G. Allan, M.A. (Bulletin No. 85.) Price, As. 4 or 5*d*.

Report.

1. Report on the Progress of Agriculture in India for the year 1917-18. Price, Rs. 1-8 or 2*s*. 3*d*.

PREFACE.

The Sixth Indian Science Congress met at Bombay in January 1919. The Agricultural Section was presided over by the Hon'ble Mr. G. F. Keatinge, C.I.E., I.C.S., and this special issue of the *Agricultural Journal of India* contains a selection of the papers bearing on agriculture and allied subjects read at the Congress. It is impossible to publish all the papers read on account of limitation of space in this issue, but the following papers will be published in the ordinary issues of the *Agricultural Journal of India* :—

(1) The Frequent Failure of a large Proportion of the Rice Crop in Chota Nagpur, by A. C. Dobbs.

(2) Note on Land Drainage in Irrigated Tracts of the Bombay Deccan, by C. C. Inglis.

(3) The Importance of the Development of the Dairy Industry in India, by W. Smith.

(4) The Improvement of Indian Dairy Cattle, by A. K. Yegnanarayan Iyer.

(5) The Prevention of Soil Erosion on Tea Estates in Southern India, by R. D. Anstead.

(6) The Fragmentation of Holdings as it affects the Introduction of Agricultural Improvements, by B. C. Burt.

(7) Results of Further Experiments and Improvements in the Method of Planting Sugarcane and Further Study of the Position of Seed in the Ground while Planting, by M. L. Kulkarni.

The paper on "Nitrogenous Fertilizers: Their Use in India," by C. M. Hutchinson, has already appeared in the *Agricultural Journal of India,* Vol. XIV, Pt. II, 1919, while that on "The Use of Poppy Seed Cake as a Cattle Food and its Effects on Yield of Milk and Composition of the Butter Fat," by H. E. Annett and J. Sen, will probably be published either in the *Journal of Agricultural Science* or in the *Analyst.*

I am indebted to His Excellency Sir George Lloyd, the Patron of the Congress, for kindly allowing his photograph to be inserted as a frontispiece to this Number, while my acknowledgments are also due to the Asiatic Society of Bengal, under whose auspices the Indian Science Congress is held, for their kindness in allowing us to publish the papers contained in this issue *in extenso*.

G. A. D. STUART,

Offg. Agricultural Adviser to the Govt. of India.

HIS EXCELLENCY SIR GEORGE LLOYD, G.C.I.E.,
GOVERNOR OF BOMBAY.

ECONOMIC FACTORS OF AGRICULTURAL PROGRESS. *

BY

THE HON'BLE MR. G. F. KEATINGE, C.I.E.,

Lately Director of Agriculture, Bombay.

GENTLEMEN,

IT is my pleasing duty to welcome you here to this session of the Agriculture and Applied Botany Section. We have before us twenty papers on a variety of subjects connected with agriculture, and I have no doubt that we shall have some very interesting discussions on these papers.

I much appreciate the compliment that has been paid to me in asking me to preside over this Section of the Science Congress, the more so since I cannot claim to be a scientific investigator. During the past 25 years, however, I have had occasion, first as a revenue officer and then as an agricultural officer, to study the economic condition of the cultivators in this Presidency, and I propose to address you on some economic factors which I conceive to be of fundamental importance in the matter of agricultural progress. Political Economy has, I believe, been described as the "dismal science." I fear that you may find my remarks dismal, but I hope that you will not find them unscientific. My excuse for addressing you on a subject somewhat remote from physical science is that I think that all you agricultural workers in this country, whether you are agriculturists, chemists, botanists or engineers, are often compelled to realize that the results of your labours, the practical application of the methods which you advocate, are largely discounted and severely handicapped by existing economic difficulties.

* Presidential address delivered before the Agricultural Section of the Indian Science Congress, Bombay, January, 1919.

You discover something which should be of great value to the community, but the economic condition is often such that hardly any one is in a position to take advantage of your discovery. This cannot fail to be very disheartening to yourselves, to the public which is looking for material advancement at your hands, and to the Governments to whom we have to look for increased support. If the existing economic difficulties were insuperable, there would be little use in railing against them ; but it is because I believe that they can be overcome and that a situation can be created in which the practical value of your labours can be greatly increased, that I venture to address you on the subject.

Stated in its briefest possible form, my proposition is this. In farming there are two fundamental units, the farm and the farmer. For agricultural progress it is necessary that the farm should be a fixed and permanent unit, so that it may admit of permanent improvement and adequate development, and that the farmer should be a fluid and moveable unit, so that the right men may get to the right places. Speaking generally, we find, to our misfortune, that in India the exact reverse is the case, that the farm, on the one hand, is subject to a continuous series of economic earthquakes, and that the farmer, on the other hand, is fixed and rooted.

To turn first to the farm. So much has been said during the last few years on the subject of the subdivision and fragmentation of holdings, and the evil has been so generally recognized, that I do not propose to go into the matter in any detail. No orderly development, no effective improvement can take place in a holding which is the wrong size and shape and which has no stability. The fact that this is true not only in theory but also in practice can be verified by any one who will take the trouble to do so. Not only is the land totally undeveloped, as development is known in other countries, but the idea of progressive development is hardly understood by the landowners. To develop and improve a permanent 10- or 20- acre farm is an intelligible proposition ; but to develop and improve a 10- or 20- acre farm which must in the near future be split up and fragmented is not an intelligible proposition to any one ; and since this is the proposition which confronts the Indian farmer

it is not surprising that he does not consider it seriously. In this way a low standard is set of agricultural methods and of agricultural results, a serious obstruction to progress is presented, and there arises a generally uneconomic situation which tends to become worse rather than better.

Now let us turn to the farmer. The farmer owns his small and fluctuating area of land, it may be 15 acres of land in three plots in one generation, and 5 acres in six plots in the next generation. The point is that the farmer is fixed and permanent. His farm may fly into fragments and grow steadily smaller, but, generally speaking, he himself persists, whether he be a good, bad or indifferent farmer. In highly individualistic and competitive countries, efficiency is secured largely by the elimination of the unfit, who are squeezed out of the race by keen competition coupled by a high standard of living. This law is in constant operation in England, and there have been periods of agricultural depression there, when unprogressive farmers have been ruined and squeezed out wholesale, while on some kinds of soil it is recognized that a bad farmer cannot hope, even in prosperous times, to survive many seasons. In rural India, however, the competition is less keen, the standard of living lower, and an easy-going tolerance, combined with an elastic joint-family system, helps to tide the less effective members over their difficulties and to keep them in their places to the obstruction of the more effective members of the community. It is by no means contended that there are no good farmers, nor can it be expected anywhere that all farmers will reach a high degree of excellence ; all that is suggested is that, owing to the causes mentioned above, the proportion of bad and indifferent farmers is unduly large. And after all it is this proportion which counts ; for while we would term a country backward in agriculture in which only 10 per cent. of the farmers were good farmers, we would be able to class it as advanced in agriculture if 50 per cent. of the farmers were advanced and progressive.

We may then sum up the situation thus—

The majority of the farms are of the wrong size and the wrong shape, they are not permanent units and are not susceptible of

orderly and adequate improvement. The majority of the farmers are deficient in skill, industry and energy, and balance a low standard of endeavour by a low standard of living.

These are the fundamental obstructions to agricultural progress to which I have to refer. The question is how we are to overcome them. It is clear that what we have to do is to endeavour to create and maintain suitably sized and suitably situated holdings which will admit of adequate development, and to arrange that there shall be nothing to prevent these economic units from passing by natural laws into the hands of the most progressive farmers who will be in a position to make the best use of them. If we can do this we can trust to the natural fertility of the soil and the natural industry of the farmers to secure the progress which we desire, aided by the scientific investigations which have been made and which will be made in future. But until we can do this we shall not secure anything like the full results that we look for from our natural advantages or from our scientific labours.

Now what is it that prevents us from taking action of the nature indicated? Whenever any remedial action of this nature is suggested it is always urged that the people have not asked for such action and do not want it, that such action would be opposed to their religion and to their sentiments, and that a shuffle of farms and of farmers would constitute a political danger. These aspects of the question must, of course, be carefully considered. This is a country where religious and sentimental ideals count for much, where political dangers must be given due weight. But there is also a persistent demand on the part of a section of the population for material progress. We have come to the parting of the ways, and India must decide which road she wishes to take. You may set up a sentimental ideal, an æsthetic ideal, an ideal of voluntary poverty, or an ideal of political caution. Such ideals are quite intelligible. The trouble is that to a large extent they are not compatible with the ideal of material progress. All that I say is this: if the former ideals are chosen to the exclusion of the latter let us stop all talk of rapid material progress; for we shall have deliberately refused to take the first steps that lead to it.

DRAINAGE AND CROP PRODUCTION IN INDIA.

BY

ALBERT HOWARD, C.I.E., *Imperial Economic Botanist*,

AND

GABRIELLE L. C. HOWARD, M.A., *Second Imperial Economic Botanist.*

THE present may be described as the era of reconstruction. Ideas which were current five years ago have since been proved obsolete. Agriculture, which is concerned with the production of food and of raw materials, is now recognized as one of the key industries of the modern world whose development must be fostered by all the resources of the State. One of the main problems before the Indian Agricultural Department is the discovery of the best means of making the soil yield a higher dividend. This involves the recognition of the factors which limit production over large areas and the discovery of the best way of putting them out of operation. One of these limiting factors is defective soil-aeration. At the Lahore meeting of the Indian Science Congress, one of the subjects discussed was the aeration of the soil and its bearing on flood irrigation in the arid regions of North-West India.[1] It was shown that successful irrigation involves more than the mere application of water and that the aim of the irrigator should be *the provision of water in such a manner as to interfere as little as possible with the aeration of the soil.* The present paper attempts to deal with another aspect of soil-aeration, namely, inadequate drainage—a matter of particular importance in many parts of India. Over large areas nourished by the monsoon, this factor bars progress. Its removal, however, is a matter which often lies outside the scope of the

[1] **Recent investigations on soil-aeration.** *Agric. Journ. of India*, **vol. XIII, 1918, p. 416.**

Agricultural Department and its mere consideration involves a multitude of other interests—those of the cultivator, the landowner, the revenue authorities, the engineer and the sanitarian. As the years pass, we are more and more impressed with the importance of drainage in the agricultural development of India and the present opportunity is taken of bringing the subject forward once more. The connection between drainage and soil-aeration is not always clearly recognized. The essence of drainage, from the plant's point of view, is the maintenance of the oxygen supply of the soil water. In the case of ordinary dry crops like wheat, all that is necessary to bring this about is an adequate gaseous exchange between the atmosphere and the pore-spaces. In water culture, of which rice is perhaps the best agricultural example, it is essential that there should be a very slow movement of oxygenated water round the feeding roots. Sometimes, when the country is flooded, dry crops have to change over for a time to water culture. As long as the flood water is in movement and the aeration of the roots is provided for, little or no damage results.

In the plains of India, defective drainage arises during the monsoon from two distinct causes. In the first place, where the soils are on the stiff side, local surface accumulations of rain-water rapidly lower the fertility. In the second place, the sub-soil water often rises to such an extent at a time when the flow of the rivers is impeded that little or no general drainage is possible over large tracts of the alluvium. These two aspects of the subject will be considered separately.

SURFACE WATER-LOGGING.

On the stiffer loams of the Gangetic alluvium, local unevennesses in the crops are very common. Any partial holding up of the surface drainage by irrigation channels and any slight concavity of the fields, due to depressions or to the misuse of iron ploughs, are invariably followed by poor weak growth which exhibits all the characteristics of nitrogen starvation. That the loss of fertility is largely due to denitrification is proved by the results of an experiment carried out at Pusa in 1910. In that year, a plot of heavy

land was purposely water-logged during the month of September in order to compare its behaviour with normally managed land on either side. Across the middle of the plots a strip was manured with 4 cwt. of nitrate of soda to the acre just before sowing the wheat. The results are given in Fig. 1, from which it will be seen that the effect of a month's water-logging was to reduce the yield of wheat by about 16 bushels to the acre.

Normal cultivation.	Water-logged during September.	Normal cultivation.
34·45	15·55	29·14
SHADED AREA TREATED WITH 4 CWT. NITRATE OF SODA PER ACRE		
35·92	25·17	26·53
34·45	15·55	29·14

The numbers in the plan are bushels per acre.

FIG. 1. The result of water-logging wheat land at Pusa in 1910.

In another case at Pusa, a portion of a rather stiff piece of land was similarly water-logged during September 1917 and sown with Java indigo the following month. The effect of the water-logging on this leguminous crop was very marked. Five months after sowing, equal areas on the water-logged and control plots were taken and the heights of the plants were measured. On the water-logged plot, the average height of 200 plants was 10·4 cm., on the control the average height of an equal number of plants was 28·0 cm. When the root-system of the plants on these plots was examined it was found that the first effect of water-logging was to restrict the roots to the upper layers during the first few months of growth and to change the general character of the root-system. The results are shown in Fig. 2. On the left is represented the root-system of a plant from the plot water-logged a month before sowing, on the right a specimen of the roots from the control plot is to be seen. In the

water-logged plot, the development of the tap-root is soon arrested and one of the laterals after bending takes its place. In the case illustrated the acting tap-root was followed to some distance and was found to give off very few branches.

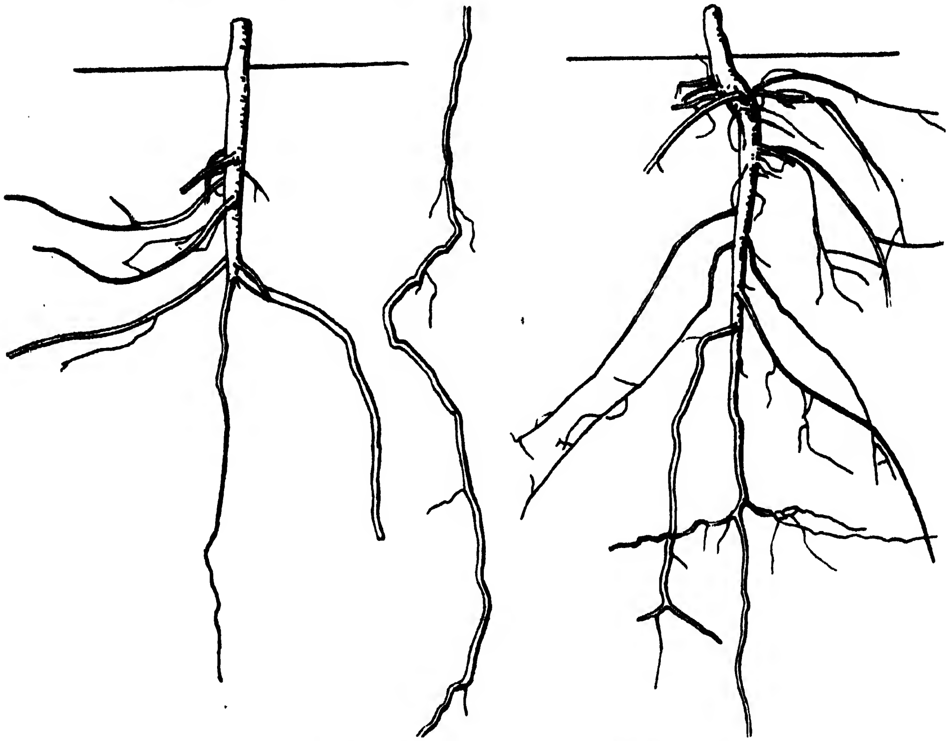
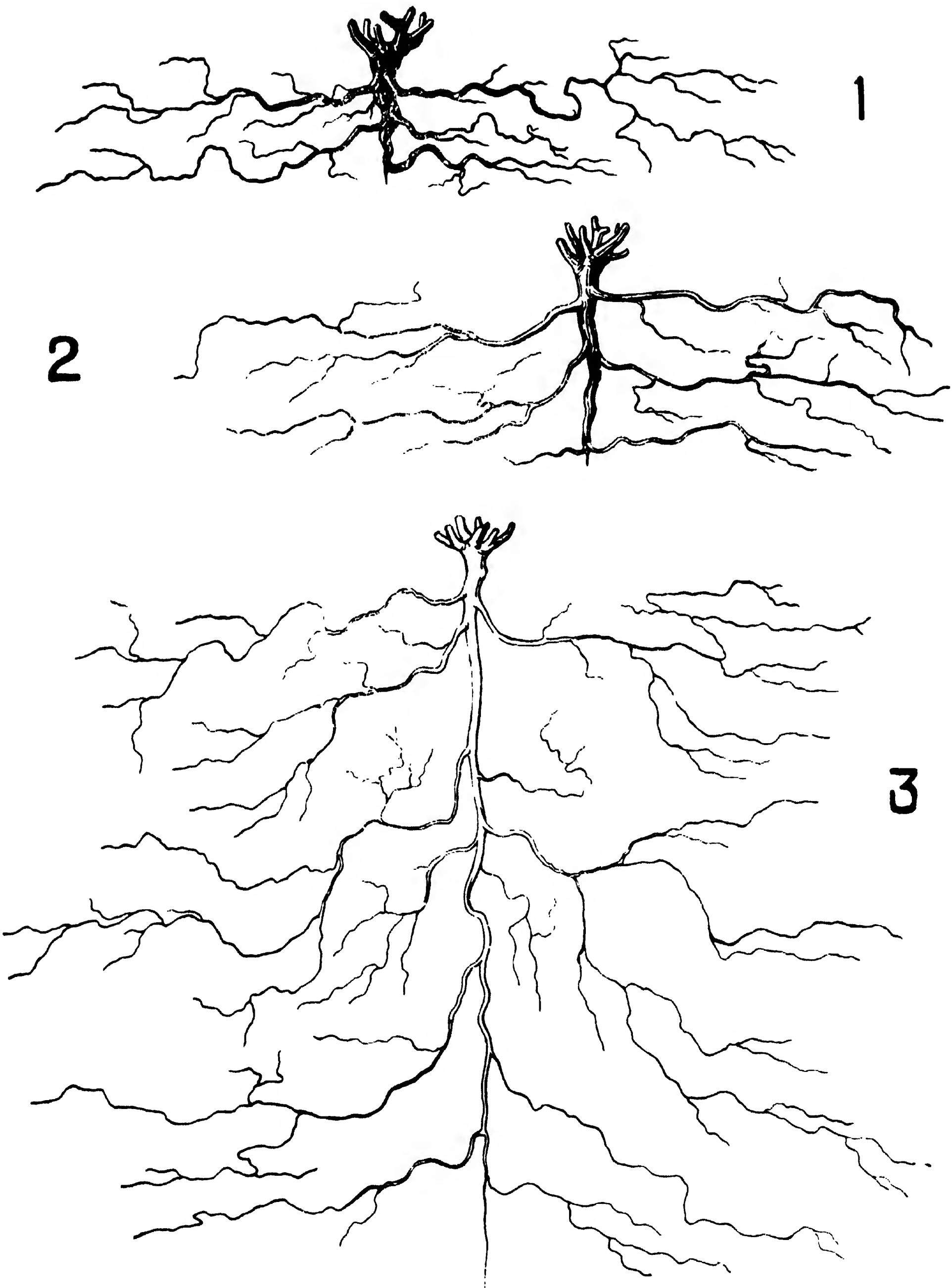


FIG. 2. The root-system of Java indigo showing the effect of water-logging before sowing (left) compared with the control (right).

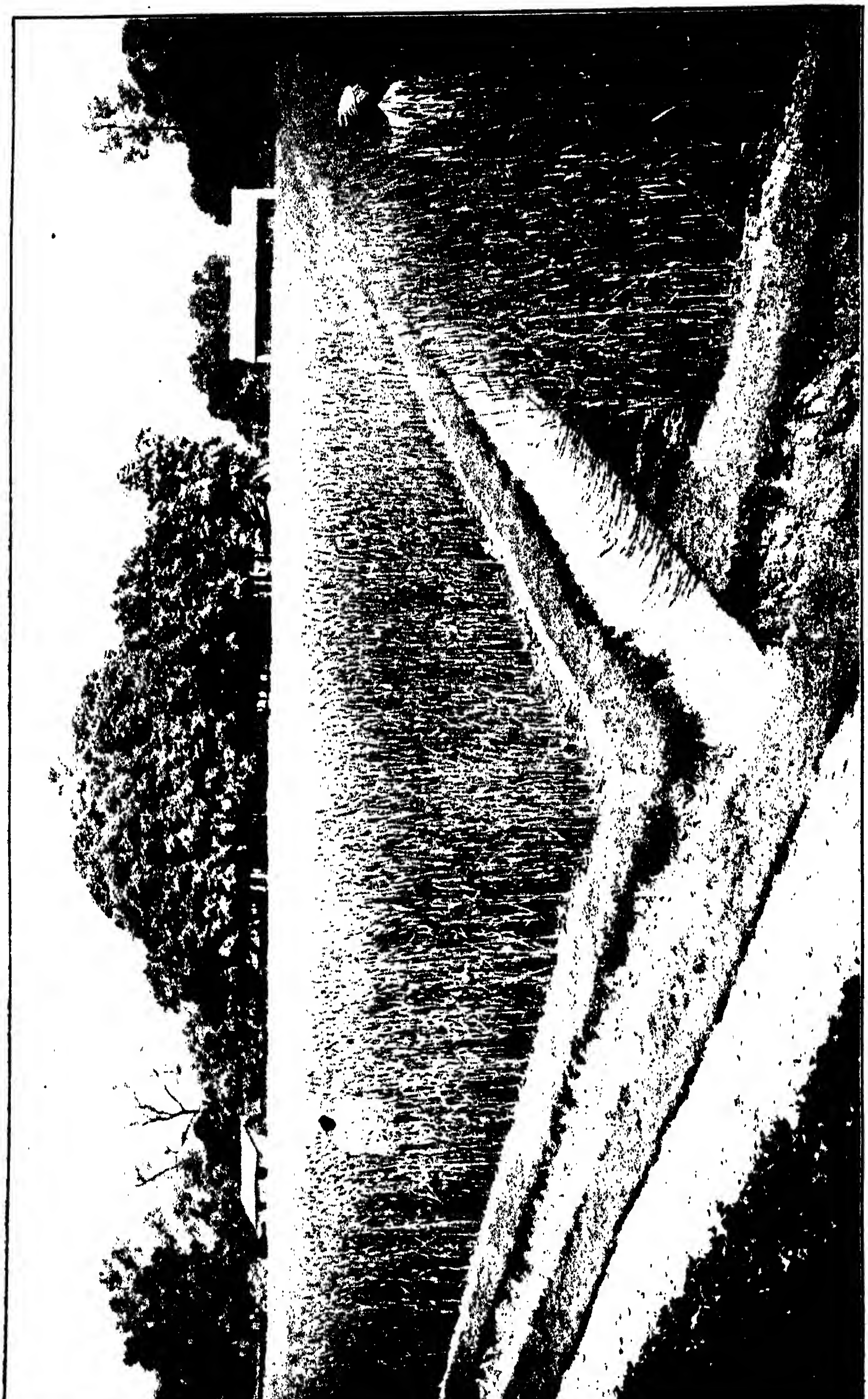
Similar results have been obtained in the case of gram. In Plate VII are represented the root-systems of three gram plants grown in Pusa soil the same year and within one hundred yards of each other. Fig. 1 represents the root-system on a heavy clay where the aeration of the sub-soil during the previous monsoon was poor. The crop did very well up to flowering time but it set no seed and wilted away. The lower figure shows the root-system of a gram plant in light land. Here the yield of seed was heavy. The middle figure shows the root-system in land intermediate in character. Here the plants did not set seed well and the yield was poor. In the gram crop, root development depends directly on the aeration of the soil and is considerably modified by this factor.

PLATE VII.



THE INFLUENCE OF SOIL-AERATION ON THE ROOT-DEVELOPMENT OF GRAM.

PLATE VIII.



SURFACE DRAINAGE AT PUSA.

The loss of fertility through denitrification is not the only consequence of surface water-logging. The physical texture of the soil is profoundly affected and when the land dries it is difficult to obtain the ideal crumb structure. The clods do not readily break down under the beam and the soil is gummy to the feel. Colloidal substances appear to be formed under these anaerobic conditions which not only hinder the formation of a good tilth but also prevent percolation. It is quite common at Pusa after a very heavy monsoon to find the pore-spaces near the surface almost entirely filled with water for some considerable time after the level of the rivers and of the ground water has begun to fall. The surface soil does not seem to be able to drain. An improvement in the texture follows if the surface drainage is improved and in cases where organic matter has recently been added to the soil. The gummy substances do not then seem to be formed to any great extent and the clods readily break down. These matters urgently require exact and careful investigation and it is difficult to suggest a more promising field of work for the soil physicist in India.

The extent of the annual loss in the plains of India due to surface water-logging will be apparent if we consider the benefits which result from improved surface drainage through the adoption of the Pusa system.[1] This method consists in dividing up the area to be drained into units not more than four or five acres in extent separated by trenches. These trenches are about four feet wide and two feet deep with sloping sides and grass borders (Plate VIII). The run-off passes over these grass borders and is led away to low-lying rice areas while most of the silt is retained on the field. By this device, each field has to deal with its own rainfall only and the run-off is strictly controlled.

The improvement in fertility and in the ease of cultivation which results from surface drainage are almost past belief. The Botanical Area at Pusa has been transformed by this means. The yields have increased, the plots produce even crops and the tilth of the stiffer areas, which was formerly poor, is now vastly improved. Several of the estates in Bihar have adopted this system which the

[1] Soil erosion and surface drainage. *Bulletin No. 53, Agric. Research Institute, Pusa*, 1915.

surrounding cultivators are now copying. As an example of the results obtained, the following report, dated November 16th, 1914, from the Manager of the Dholi estate may be quoted :—

"I have now some 500 bighas at Dholi and my outwork, Birowlie, drained by surface drains on the Pusa system.

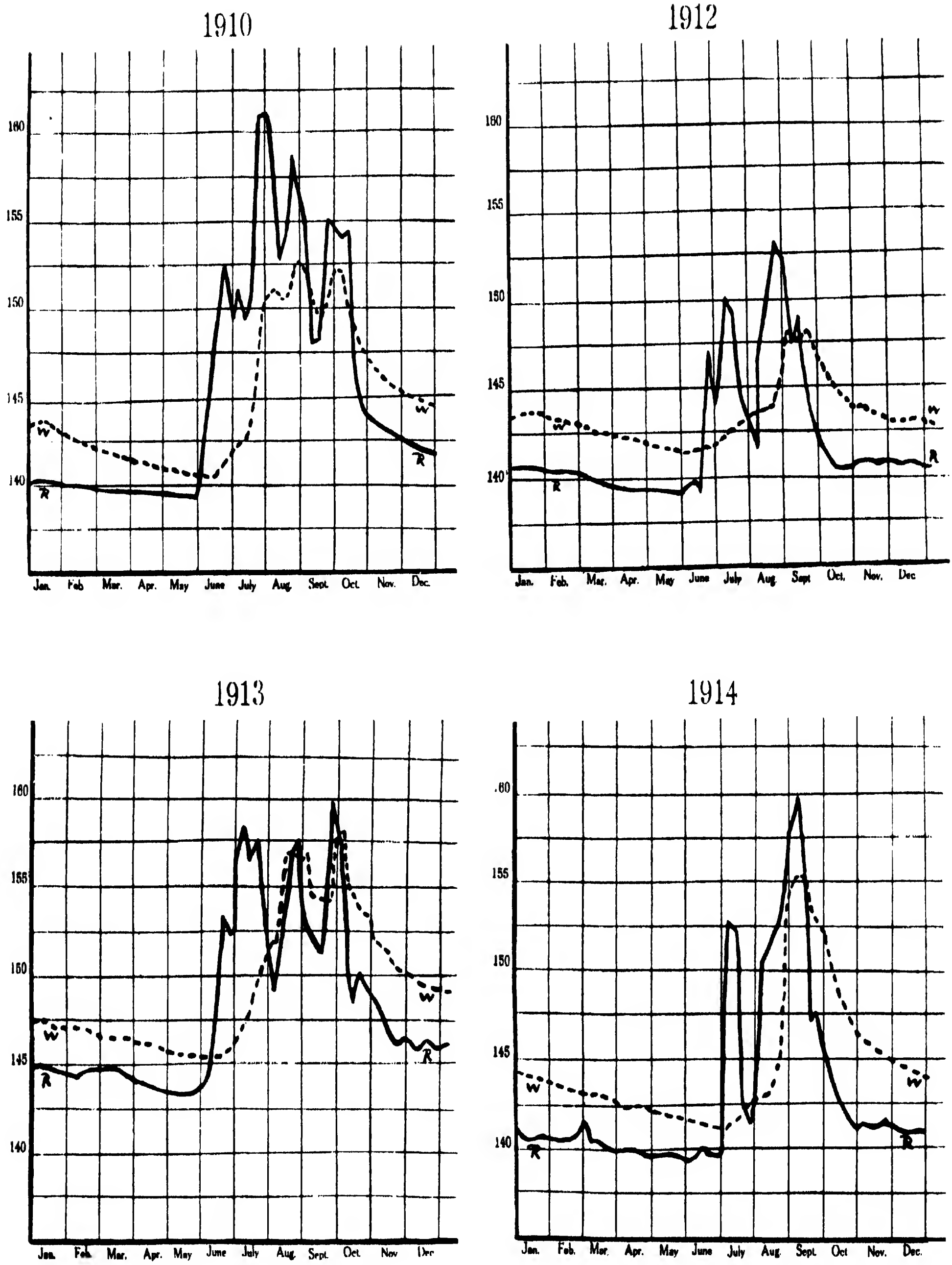
"The improvement of all the lands is very marked, especially at Dholi where most of the lands are on a slope and the high lands suffered from loss of soil from rain-wash and the lower lands used to be water-logged at the time when they should be cultivated for *rabi* and indigo crops.

"The advantage derived from the drainage is most marked in the low-lying lands which were formerly my poorest lands and these last year gave me as good or better returns of wheat and indigo than the high lands; and I am certain will still further improve. These lands I am now able to keep cultivated through the rains and to sow them at the same time as the higher lands."

The most convincing proof however of the advantages of the adoption of this system on the Bihar estates is to be found in the rents paid by the tenants of drained land. On the Dholi estate, several areas, which previously could not be let to tenants at all and which had to be put under cheap crops like oats, fetched high rents when surface drained. In 1914, one of these drained areas under chillies was let for ninety rupees a bigha, another under tobacco for one hundred and fifty rupees a bigha. The improvement in soil-aeration which followed the construction of the surface drains thus rendered possible the substitution of money crops for cheap crops.

The prevention of drainage.

Another aspect of drainage must now be considered. As the rain-inundated region of the Gangetic delta is approached, a well-marked rise in the sub-soil water-level takes place after the monsoon has set in. This is particularly the case in North Bihar where the flow of the rivers is soon checked by the rise of the level of the Ganges. The result is that the rivers overflow and the low-lying areas go under water. The rise in the level of the rivers is followed



CHANGES IN THE RIVER AND WELL LEVELS AT PUSA.

The well levels are shown by dotted lines. The observations are expressed in feet above mean sea level.

by a rise in the water-level of the wells. These movements of the river-level and of the general ground-water are illustrated in the curves opposite which represent the state of affairs of the river at Pusa and of one of the wells (about a quarter of a mile distant from the river bank) for the years 1910, 1912, 1913 and 1914. These curves (which were prepared by Mr. Jatindra Nath Sen when Officiating Imperial Agricultural Chemist at Pusa) are typical of the sub-soil water conditions of this tract during the monsoon. It will be seen that the curves of the ground-water level vary according to the year. In some years like 1912 and 1914, the curve is even and no great oscillations of level occur. In others, such as 1910 and 1913, there are well-marked oscillations. These oscillations, from the plant's point of view, are of the greatest importance as a fall in the level of the ground-water means a strong downward pull and the temporary resumption of drainage and of soil-aeration.

These Bihar ground-water and river-level curves have proved to be of particular interest in the study of the wilt disease of Java indigo. It is found that this deep-rooted plant ceases to thrive when the general drainage of the country stops and often dies off altogether due to wilt. It appeared from numerous observations in the field that indigo wilt is caused by water-logging which leads to the destruction of the fine roots and root nodules. This view has been established by direct experiments in lysimeters in which the drainage can be stopped at will. At the beginning of the monsoon of 1918, Java indigo was grown in two sets of lysimeters. In one set, alluvial soil obtained from the Kalianpur farm near Cawnpore was used, in the other set, light Pusa soil was employed. The Kalianpur soil is exceedingly rich in available phosphate (0·318 per cent.) while the Pusa soil, when analysed by Dyer's method, gives very low figures for available phosphate (0·001 per cent.).

The results may be summed up as follows :—

(1) In both Pusa and Kalianpur soil the indigo in the lysimeters with free drainage escaped wilt.

(2) When the drainage openings were closed and water-logging from below took place, all the plants were wilted in both Kalianpur and in Pusa soil.

(3) The wilt in the Kalianpur soil (rich in available phosphate) was much worse than in Pusa soil (said to be low in available phosphate).

(4) The growth in Kalianpur soil was much slower than in Pusa soil.

In these lysimeter experiments, the stoppage of drainage brought about an interesting change in the root-system of the indigo and caused the lateral roots to run near the surface. (Fig. 3.)

FIG. 3. The effect of water-logging after sowing on the root-development of Java indigo.

On the left are shown two indigo plants from the lysimeter with free drainage. The root development is normal for the variety sown. On the right, two typical plants from the lysimeter in which the drainage openings were closed are represented. Here only surface roots were developed and the main tap-root was restricted.

SUB-SOIL DRAINAGE.

Another aspect of drainage must now be briefly considered, namely, sub-soil drainage by means of tiles. The openings for this system in India under present conditions are however much fewer than for surface drainage. The cost per acre of laying tile drains is considerable and further, if the work is to be of use, it must be well done. Sub-soil drainage would naturally only be attempted if surface drainage is found to be insufficient to improve the aeration of the soil. The heavy, black soils of peninsular India afford perhaps the best opening for this class of soil improvement. As is well known, these soils expand when wetted and the crops only do well if the amount and distribution of the rainfall is particularly favourable. Heavy, long-continued rain is almost as harmful as actual famine conditions. Particularly is this the case with cotton which never yields well in wet years. Interesting and valuable results have been obtained by Mr. Allan on the heavy black soils at Nagpur where, by means of sub-soil drainage, marked improvements have been shown possible.[1] By means of shallow sub-soil drains, Mr. Allan obtained the following advantages :—

(*a*) Surface cultivation is rendered possible even in wet years and the land can be kept clean.

(*b*) The crops grow faster, are healthier and yield better.

(*c*) The root development is improved and the resistance to drought is increased.

Mr. Allan's results were obtained on the ordinary heavy black soils at Nagpur. The most productive of this class of land, however, are the garden lands irrigated by wells or tanks. These fields are very valuable, are often well cultivated and large quantities of manure

[1] **Allan, R. G.** ***Bulletin No.* 85, *Agric. Research Institute, Pusa,* 1918.**

and irrigation water are annually applied. They suffer little from erosion as they are constantly under crop, the surface is generally even and the area of each field is small. By means of sub-soil drains discharging into irrigation wells it *might* be possible not only to increase the yield and the number of crops per year but also, by improving the aeration, to diminish the amount of manure and irrigation water required. There seems to be a very promising field of investigation in developing the rich garden lands of the Bombay Presidency and the old poppy fields of the Malwa plateau. Already a great deal of capital has been sunk in these fields. Their owners are often well-to-do men who could easily afford to sink some of their savings in sub-soil drainage if this proves to be a success. The matter is one well worthy of careful investigation.

THE WIDER ASPECTS OF DRAINAGE.

While the cultivator can often do a certain amount to improve the surface drainage of his fields he is quite unable to cope with the larger aspects of the subject. Observations indicate that in many parts of India the surface drainage of large areas is defective and the crops suffer from poor soil-aeration. In some cases, this is due to the existence of extensive shallow, cup-shaped depressions which are unable to discharge the run-off quickly. In others, the genéral surface drainage is partially held up by roads, embankments and by bridges provided with insufficient water-way. Such problems are clearly beyond the means of the zamindar. They need for their solution the services of the engineer. A detailed drainage map of the area to be improved is obviously the first condition of success. From an inspection of some of these areas in the plains it would appear that a great deal could be done by the provision of a system of drainage canals by which the run-off can be passed either into rivers or led slowly through rice areas at a slightly lower level.

The difficulty in matters such as these is to make a successful beginning. The first step appears to be the study of the general drainage of a few of these partially water-logged tracts of the alluvium, the preparation of a drainage map combined with a study

of the rivers where this is necessary. The drawing up of definite working-plans would follow and progressive landowners would probably be found who would be willing to execute a small project under direction. These proposals do not involve a great deal of expense. A certain number of engineers with the necessary agricultural insight in all probability exist in the country now and, if set to work on this question, would rapidly justify themselves. Their assistance in this matter is essential. The cultivators and zamindars are so intent on their own small areas of land that they cannot be expected to evolve a scientific scheme of drainage for the country-side. Clearly it is for the State to provide a directing hand. In this direction a step forward has already been made by one Indian province. In the *Punjab Government Gazette* of September 28th, 1918, the constitution and duties of a Drainage Board for the province were announced. In the Government Resolution on this matter it is stated that " water-logging is due to many other causes than seepage or over-irrigation from canals, for instance imperfect natural drainage or the obstruction of natural drainage by roads, railways, irrigation channels and zamindars' embankments. The evil is of steady growth in parts of the province and in some places threatens not only the prosperity but the health of the rural population and involves also serious loss to Government revenue. Hitherto it has been dealt with only spasmodically. There has been no settled policy either for investigation or for action. The question should, therefore, now be taken up for the province as a whole."

NOTES ON THE "RING DISEASE" OF POTATO.

BY

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AND

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In the potato tracts of the Bombay Presidency the greatest enemy to the successful growth of this crop is the presence of the "ring disease." Other pests and diseases exist, but they can more or less be kept in check, but in the case of the ring disease, the cultivators have been helpless, largely because they have not been able to determine the source of the disease, and the means by which it is transferred from crop to crop. In the past, the regular and frequent importation of fresh seed from Italy has been the method adopted to keep the disease in hand, but it was never determined whether the success of this method was due to greater resisting power in the imported seed, or whether its gradual deterioration was due to continually increasing infection after importation. During the years since 1915 the import of such seed has been impossible, and the question of keeping the disease in check while using local seed became a matter of urgent necessity to the potato industry.

The ring disease of potato, it may be noted, is a bacterial wilt and though its ravages had proved a very serious matter in Bombay as long ago as 1891, it was only accurately investigated and its nature determined by Coleman in 1909. Its attack produces a sudden wilting of the plant, when such tubers as are attached to

the plant will be found to show a brown ring in the vascular tissue, commencing as a rule near the point of attachment of the tuber to the plant, but spreading round the whole tuber. The infection also affects the lower part of the stem in which the ring can usually also be distinctly seen.

The damage done by the disease is very great. Often twenty or thirty per cent. of the plants in a plot die, and we have known as much as seventy or eighty per cent. of what seemed at one time a very promising crop to be lost on account of the disease. It is almost universally found in the potato-growing tracts of the Deccan.

The most important point in combating this disease is to find the usual means of infection. It has been known, since the investigations of Coleman (1909), that diseased seed tubers would produce diseased plants, and, moreover, that infection could also take place through infected soil. But the relative importance of these methods in actual practice has not been determined and it was absolutely necessary to our work to find out how the disease was most frequently carried from crop to crop. In other words, if soil infection was the *chief* source of the disease in our fields, it would be necessary to fight the disease by keeping infected fields free from susceptible plants until the bacteria which cause the disease die out. If, on the other hand, the seed was the chief means of infection, careful attention to the seed would be the primary, and might even be the only necessary, method of precaution.

The determination of these points was the object of a series of pot experiments in 1917 and 1918, in which potatoes were grown in fresh river soil in which no infection could have occurred, and infection was introduced in the following ways :—

(1) by planting potatoes containing ring disease;
(2) by mixing pieces of potato attacked by ring disease with the *soil*;
(3) by watering the *soil* with water in which cut sets of potatoes attacked by ring disease had been allowed to lie for half an hour;
(4) by inserting pieces of potato infected with ring disease in the potato *sets*;

(5) by soaking the potato *sets* in water used to wash potatoes affected with ring disease;

(6) by using, *as seed*, tubers from a plant affected with ring disease, but which themselves showed no sign of the disease;

(7) by using a knife infected by cutting affected sets, to cut sound potatoes for planting;

Duplicate pots were taken in each case, but the results were consistent throughout, and gave results as follows :—

(1) Where diseased potatoes (eight sets) were planted.

(*a*) Six sets did not germinate;

(*b*) one set germinated, but began to wither eleven days later, and was completely dead after a week;

(*c*) one set germinated and grew fairly well. It however produced no tubers, and after ripening the original set was found to be rotten.

(2) Where the *soil* was infected with fragments of infected potato. Six sets were planted, and all germinated. Seven days later one was wilting. After eleven days two plants were dead and two were wilting. A week later one more was dead, but the other affected plant was making an effort to throw out new buds. It was in vain however, and seven days after it was dead. At this time (4½ weeks after planting) all were affected and either dead or dying save one plant. This latter remained apparently healthy and matured normally giving three ripe tubers. On cutting these, however, all were found showing signs of ring disease in the tuber.

Infection of the soil by fragments of diseased tubers is, therefore, very fatal, and even if the plants do not die, the tubers are very likely to be diseased.

(3) Where the *soil* was infected by the water in which diseased potatoes had been soaked.

Five sets out of six germinated, but all died of ring disease. They were quite healthy, however, for over

three weeks, and then wilted and died in rapid succession. After six weeks all were dead.

This experiment shows the extremely infective character of the water in which diseased sets have been soaked.

(4) Where the *sets* were infected by the insertion of fragments of diseased tubers.

The results of this method of infection showed it to be by no means so certain or so rapid as those previously considered. Out of six plants, one died in six weeks, and two more a week later. The remainder (3) ripened and were harvested in due course three months after. Of the tubers produced, those from one plant all showed signs of ring disease, from a second all showed signs except one and in this none could be detected, while in the third no ring disease could be observed in any of the tubers produced.

(5) Where the *sets* were infected by soaking in the water in which diseased potatoes had been placed.

In this case all the potatoes germinated normally. The first sign of disease was observed twenty-four days later, but the progress was very rapid and all were dead thirty-six days after planting.

(6) Where the *sets* were from infected plants, but themselves showed no signs of ring disease.

Out of eight such sets planted two died of ring disease five weeks after planting. The remainder were harvested but *all the tubers produced showed signs of ring disease.*

This experiment showed clearly that the potatoes which were obtained from ring-disease-affected plants but showed themselves no sign of the disease were unsafe as seed.

(7) Where the sets, though healthy, were cut with a knife previously used to cut a potato affected with ring disease.

Fifteen healthy potato sets were planted, their only connection with the disease being that the knife used

for cutting them had previously been used to cut diseased potatoes. Fourteen sets germinated in due course and in good time. A month later five of them were dead, and gradually all died before maturity except two. These two matured, but all the tubers on them were half rotted with ring disease when they were taken out.

This experiment shows the extreme infectiveness of the disease.

The position is, therefore, clear. The ring disease is extremely infectious and may be carried by diseased sets or by anything which has been in contact with them. The soil may carry the disease whether it has been infected by diseased tubers, by water in which diseased tubers have been washed, or by remnants of diseased potato plants remaining in the soil. And even the knives used for cutting a few diseased tubers may infect a large part of a crop, when the seed is otherwise of good quality. This last fact is beginning now to be realized by the cultivators, and we are introducing a system of sterilizing the knife used for cutting sets with hot water after contact with diseased potatoes, among the more advanced cultivators of the Poona potato tract.

Perhaps the chief interest, however, lies in the infection through the soil, and the length of time during which the bacteria are capable of living there, and infecting the following crop. It is obvious that if the organism is capable of making soil infective for a long period potato cultivation is doomed in these districts. We have hence made experiments to ascertain how soon potatoes can again be safely grown after the soil is thoroughly infected with the disease.

Pots were taken in which all the plants had died through soil infection with water in which diseased sets had been soaked, but from which all remnants of diseased plants were removed. Then new healthy sets were planted (1) immediately, (2) after two to three months, and (3) after about six months. In the meantime the soil was allowed to stand without cultivation.

Where healthy potato sets were planted immediately after the removal of the previous (diseased) crop, all the plants were affected;

out of four plants one died within three weeks of planting, another within four weeks, while a month later a third was dead. The fourth was attacked, but was able to throw out new side shoots and came to maturity. No tubers were however formed. In this case, therefore, all plants were affected.

The soil from which the last crop was harvested was then allowed to stand for two and a half months (November 1st to January 18th) and then re-planted. Four plants were obtained. Three remained healthy throughout, produced good tubers which showed no sign of ring disease. The fourth plant began to droop after three months, and was then dug up. Of the three potatoes produced by this plant, two were apparently healthy, but the third was undoubtedly attacked with ring disease.

The same pot was again sown a week later (eleven months after the original infection), the plants matured healthily and the tubers showed no sign of ring disease.

In a further experiment, the soil was thoroughly infected with diseased material and healthy sets planted immediately. All died in due course, and then, after removal of the plant residues, the soil was allowed to stand for five months without a crop (August 18th to January 18th). It was then planted with healthy sets. Under these circumstances all the sets germinated perfectly, grew healthily and ripened normally. No tuber or plant showed any sign of ring disease.

As this matter appeared very important the experiment was repeated with no less than nine pots in all of which the soil was thoroughly infected as shown by the complete loss of the previous crop. In each case, after removal of the plants, the soil was allowed to stand for 6½ months (September 11th to March 27th) and then planted with healthy sets. All germinated, and no sign of ring disease was found throughout growth. None of the tubers produced were infected with ring disease.

In summary, we may say that the experiments recorded confirm previous results as to the conveyance of the ring disease of potatoes from crop to crop both through the seed and the soil. They show the extremely infectious character of the disease in that not only the

seed but also everything which has been in contact with it, even the knife by which diseased sets have been cut, are capable of conveying the disease to a healthy tuber and hence to a healthy plant.

The infection does not, however, live long in the soil in a virulent enough condition to affect new plants. After two and a half months the infectiveness was reduced by at least seventy-five per cent. After five to six and a half months the infectiveness of the soil has disappeared.* It would appear clear, therefore, that if land is kept free from potato plants, or other plants, like tobacco, capable of carrying the disease, for six months, the danger of infection through the soil is very small, if, indeed, it is not entirely eliminated. Inasmuch as the potato crop, usually reaped in February or March, is never planted on the same land until October or November, and the crop reaped in September or October is never planted on the same land until the following June, it would appear that the danger of infection through the soil under Deccan conditions is small, if the diseased plants are carefully removed in each crop. This agrees with practical experience and enables attention to be focussed on the provision of disease-free seed as the main line of the attack on this very fatal disease.

* As against this, Butler reports that five years are considered as necessary in America to remove the infectiveness of the bacterial wilt of tobacco caused by the same organism.

RATE OF NITRIFICATION OF DIFFERENT GREEN MANURES AND PARTS OF GREEN MANURES AND THE INFLUENCE OF CROP RESIDUES ON NITRIFICATION.

BY

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Green-manuring is a subject of world-wide interest, as the practice is in vogue in all countries and has proved effective in maintaining or increasing the fertility of the soil. In support of this practice of ploughing in a green crop into the soil various reasons are usually given. However, analyses of soil, before and after green-manuring, have shown that the organic matter and the nitrogen added to the soil by the green crop are of all others the two most important factors on which the value of green-manuring chiefly depends ; and field trials on a large scale have further made it evident that the practice is an economical one, that is, it can at a comparatively smaller cost per unit provide the organic matter and the nitrogen necessary to improve the soil.

In green-manuring the changes brought about by the addition of large amounts of organic matter are no doubt an important asset as affecting the general permanent fertility of the soil by increasing its humus content and improving its physical property, but what is of immediate benefit to the crop succeeding the green manure is the addition of nitrogenous material which becomes readily available by being changed into nitrates in which form the nitrogen is mainly taken up by plants. In order to convert the organic matter into humus and the nitrogenous material into nitrates it is necessary

that green manure should first be thoroughly decomposed. The conditions necessary for the decomposition of a particular green crop cannot be found everywhere as there are many variations in conditions of soil and climate in different countries. Hence different kinds of green manure have been tried under varying conditions of soil and climate all over the world. These empirical trials have yielded plants for green-manuring purposes suitable to each particular area, but in spite of the fact that the course suggested by empirical trials is followed in practice and is usually attended with success, still many times failures also occur. There are numerous such instances on record of the failure of the treatment of the soil with green manures to promote greater fertility. It is difficult at first sight to account for the absence of the specific effect of the addition of organic nitrogen on crop yield. This is no doubt due to the paucity of research from the biological side of the question. However, besides the work done in other countries some valuable results of work done by the Agricultural Departments in India are already published. The work on the gases of swamp rice soils by Harrison and Aiyer[1] deals with the practice of green-manuring for rice and hence does not relate to conditions obtaining in the use of green manures for the succeeding *rabi* (winter) crops. This latter aspect of the question is dealt with by Hutchinson and Milligan[2] who have studied the decomposition of green manures from a bacteriological point of view in the laboratory, besides carrying out a number of experiments in the field. These authors used sann-hemp as green manure and carried out their experiments in Pusa soil under varying conditions of moisture and depth of burying the green manure in the soil. As the result of their work they have made it clear that the value of green manure depends on the presence of proper conditions of moisture in order to effect its complete decomposition, and that rainfall and transpiration of water from the green manure crop itself affect the moisture left in the soil for the successful decomposition of the green manure. Another point of importance to which

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[1] Harrison and Aiyer. "The gases of swamp rice soils." *Memoirs, Dept. of Agric., India, Chemical Series*, vol. III, no. 3.

[2] Hutchinson and Milligan. *Agric. Research Inst., Pusa, Bulletin No. 40.*

attention is drawn by the authors relates to the concentration of nitrogen. The authors point out that in case of nitrogenous manures a certain concentration of nitrogen in the available condition is necessary to show the beneficial manurial effect. These observations account for many failures of green manures and also indicate the optimum conditions necessary for successful decomposition of green manures.

It is proposed in this paper to present the results of an attempt to study, on similar lines, as to what happens to green manure when incorporated in the soil for the succeeding *rabi* crop. In order to exclude the possibility of failure to decompose we restricted ourselves under previously determined optimum conditions of moisture, temperature and nitrogen concentration mentioned by Hutchinson and Milligan[1] as necessary for successful decomposition of sann-hemp. We have however extended our work to the study of decomposition of different kinds of green manures in order to find out whether there is anything in the nature of the constituents of different green manures, which makes one kind of green manure more suitable than another. We have also included in our work the study of the decomposition of different parts of green manure—leaves, stems and roots—incorporated separately in the soil, in order to ascertain whether the different ratio of nitrogenous to non-nitrogenous constituents existing in the different parts affects the course of nitrogen changes. We have also attempted to find out what happens to the undecomposed tissues or crop residues and to see the effect of the same on the process of nitrification.

Before proceeding we may just mention that in our opinion the value of green manure depends on the fact, whether after its decomposition it is able to provide a certain amount of available nitrogenous food and not so much on the quantity of organic material which it is likely to add to the soil. The soils to which green manures are added do already contain a much greater amount of organic nitrogen than the quantity added in the form of green manures. Thus Pusa soil representing the type of soils in the Gangetic alluvial

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[1] *Loc. cit.*

plain is found to contain 70 to 90 milligrams N per 100 grams of soil or 1,750 to 2,000 lb. per 9-inch acre, while the nitrogen added as green manure to the soil is from 1·5 to 2·0 milligrams per 100 grams of soil or 37 to 50 lb. per acre. But the large difference it makes to the immediately succeeding crops is due not to the actual amount added but what happens to it after it is incorporated in the soil. If we examine the original soil and the same soil to which green manure has been added after some weeks we find slight differences in the amount of total nitrogen, but of this only a small percentage is found as nitrates in the original soil, while under optimum conditions nearly 60 per cent. (under field conditions slightly less) of the added nitrogen is generally found nitrified. We say "generally" because it will be shown later that this may not be correct for all green manures. That there is a direct relation between the nitrates present in the soil and the growth of the crop is observed by all investigators, but it is worth noticing the singular coincidence between the interval necessary for maximum accumulation of nitrates after incorporation of green-manuring material as found in the laboratory and the optimum interval that should be allowed to pass after burial of the green manure before the sowing of the succeeding crop. The period for maximum accumulation of nitrates was found to be eight weeks at Pusa by Hutchinson in case of sann-hemp (*Crotalaria juncea*) as green manure in Pusa soil and the optimum interval for transplanting tobacco after sann-hemp buried as green manure was also found to be eight weeks by Howard. Another case of nitrate accumulation and the benefits to succeeding crops is noticed by J. Sen in a recent number of the *Journal of Agricultural Science* (Vol. IX, No. 1), wherein the author says :" It is also interesting to note here another point which shows a close relation between the growth of plants and the nitrification processes going on in the soil. The period during which nitrates began to accumulate in the soils investigated coincides with one of the periods of rapid plant growth in Bihar." We may take it for granted therefore that nitrate formation or rather nitrate accumulation largely influences the growth of succeeding crops, and hence attention was first given to the study of the nitrate formation in preference to all the multiple

processes that take place in the soil after the incorporation of any organic material and which we shall have occasion to discuss later on. The results obtained so far are detailed in this paper as being of interest to other workers in the field, and also with a view to invite criticism so as to enable us to direct our efforts in the proper direction in the light of these criticisms.

Six leguminous plants were chosen for the purpose of the experiment. The plants selected ranged from those possessing very thin and slender stems to those having thick woody ones. The average size of their branches is represented in the accompanying

1. Sann-hemp. 2. Dhaincha. 3. Tamarind. 4. Guvar. 5. Cow-pea. 6. Gokarn.

photograph so as to give an approximate idea of their respective size at the time of burying them in the soil. Of these the first three are of the woody and the last three of the succulent type. Their common and botanical names are as under :—

Sann-hemp (*Crotalaria juncea*).
Dhaincha (*Sesbania aculeata*).
Tamarind (*Tamarindus indica*).
Guvar (*Cyamopsis psoralioides*).

Cow-pea (*Vigna catjang*).

Gokarn (*Clitoria ternatea*).

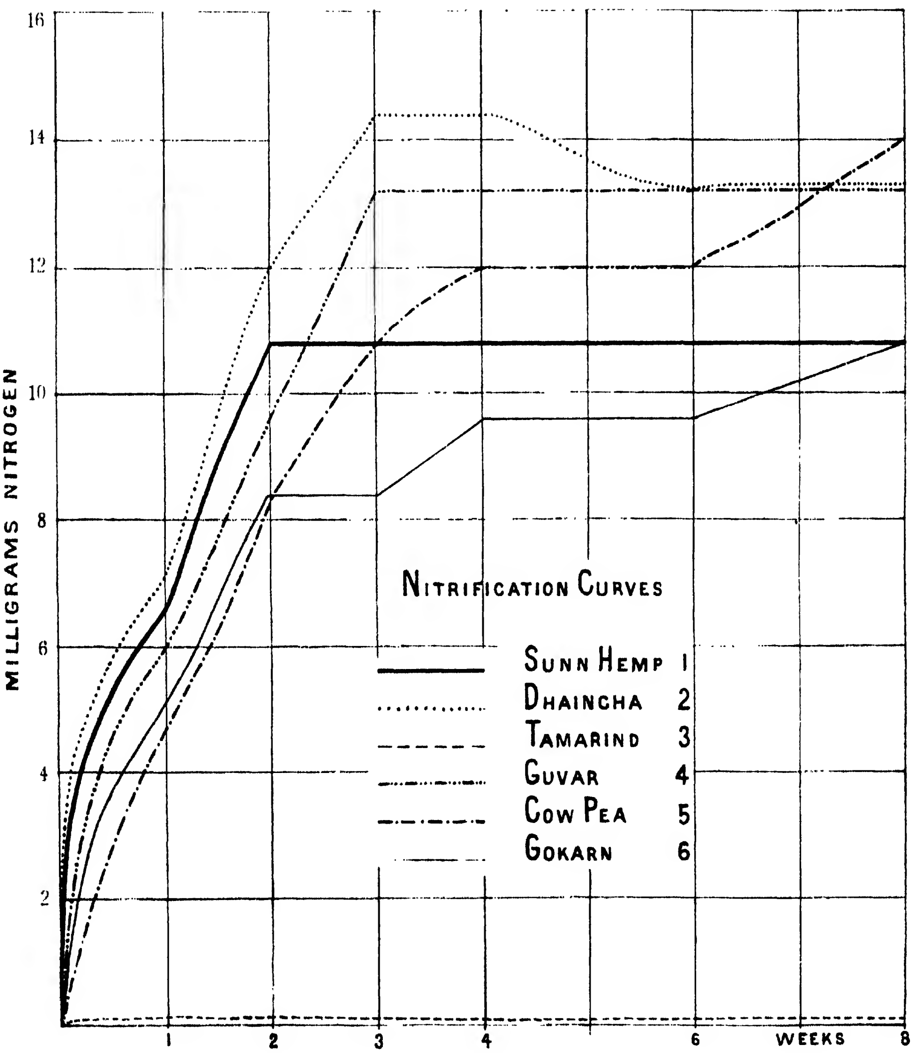
Of these, sann-hemp, *dhaincha*, *guvar* and cow-pea are commonly used as green manures. Tamarind was included with a view to see the effect of a greater proportion of woody tissue to the leaves, and *gokarn* for the opposite reason having the slenderest stem of all with a comparatively higher amount of foliage.

Seeds of these were sown separately in a small plot so as to allow their growth in the same soil as was to be used later on for nitrification experiments and under the same conditions. This process, it was thought, would avoid all the other factors likely to be urged to discount the results obtained if the crops were got from the different fields.

The plants were allowed to grow for six weeks when they were uprooted and the percentage of nitrogen was determined in each case after proper sampling. Whole plants were taken root and all. Green plants were cut to pieces, averaging about half an inch, and these were separately added to each kilo of air-dry Pusa soil at the rate of 30 milligrams of organic nitrogen in the form of green manure per 100 grams of dry soil. Water was added to the soil so as to make up the moisture content of the soil up to 16 per cent., allowance being made for the water already contained in the green plants. The soil and the plant were thoroughly mixed with the hand and each lot filled in separate glass jars. The jars were covered and kept at 30°C. in the incubator. The quantities of nitrogen and moisture stated above were taken as they had been found to be the optimum for the Pusa soil. Samples for analysis were taken after thoroughly mixing the soil, to determine the amount of ammonia, nitrite and nitrate formed at the end of each week for the first four weeks, after which time determinations were made after an interval of two weeks. Nitrates were determined by the phenol-sulphonic acid method, nitrites by Greiss-Ilosvay method, and ammonia was determined by distilling with magnesia the acidified soil extract.

Chart I illustrates the rate of nitrate formation or more correctly speaking nitrate accumulation in the soil after addition of the green manure.

CHART I.


16
14
12
10
8
6
4
2
MILLIGRAMS NITROGEN
1
2
3
4
6
WEEKS
8
NITRIFICATION CURVES
SUNN HEMP 1
DHAINCHA 2
TAMARIND 3
GUVAR 4
COW PEA 5
GOKARN 6

The result with tamarind plants is a negative one. Want of nitrification cannot in this case be attributed to insufficient moisture or low temperature as the experiment was carried out under optimum conditions of moisture and temperature and rate of application of nitrogenous material. It is striking as it is generally assumed that all legumes enrich the soil by supplying organic nitrogen and that all organic nitrogen in any form added to the soil is nitrified to a certain extent. There is no change in the reaction of the soil which remained basic. It may as well be mentioned that under the optimum conditions of moisture and temperature, decomposition of the tamarind plant tissue and also ammonification to a certain extent had taken place. The failure to nitrify therefore is not due to want of decomposition but may be regarded as due to some substance present in the plant which actually inhibits the action of nitrifiers. Experiments are in progress to find this out and we must await the results of further inquiry before we can definitely ascribe this result to any particular cause.

The rate of nitrification of the succulent plants in this experiment is in inverse ratio to the succulence of the stems; the more tender and hence more easily decomposable the tissue, the slower the nitrification: which is rather contrary to general expectation. It is assumed on *a priori* grounds that the more succulent a plant is, the more easily it is decomposed, and hence more easily available the nitrogen contained in it should become. That it is easily decomposed is correct, but on account of the very fact of its easy decomposition the nitrate accumulation power is lowered in the beginning. To venture an explanation of the fact certain possibilities present themselves which may be put down here briefly. Of these the first two explain why nitrate formation may be retarded, and are based on the assumption that nitrates accumulated in soils represent the total quantity of nitrates formed.

1. Most of the species of putrefactive bacteria that develop on the addition of green manure to a soil can attack both carbonaceous material as well as nitrogenous, and, as a result of some preliminary experiments on the subject, we found that when pure

cultures of some of these putrefactive bacteria were separately inoculated into peptone solutions with and without glucose a comparatively smaller amount of ammonia was obtained by distillation with magnesia from peptone with glucose than from peptone alone. Similar results were obtained with the complex soil flora acting on oilcake with and without glucose. We, therefore, assume that the course of nitrification will be similarly affected by easily decomposable carbonaceous material which is found in greater proportion, in the form of parenchymatous tissue, in the succulent plants than in the woody ones. It is in our opinion on account of the presence of this greater amount of easily oxidisable carbonaceous material in the succulent tissue that we get a smaller amount of nitrogenous material changed into ammoniacal condition and consequently less nitrification in the succulent plants than in the woody ones in the early stages of decomposition. It must be admitted that this explanation is a tentative one. It may have to be abandoned if further experiments do not confirm the results already obtained.

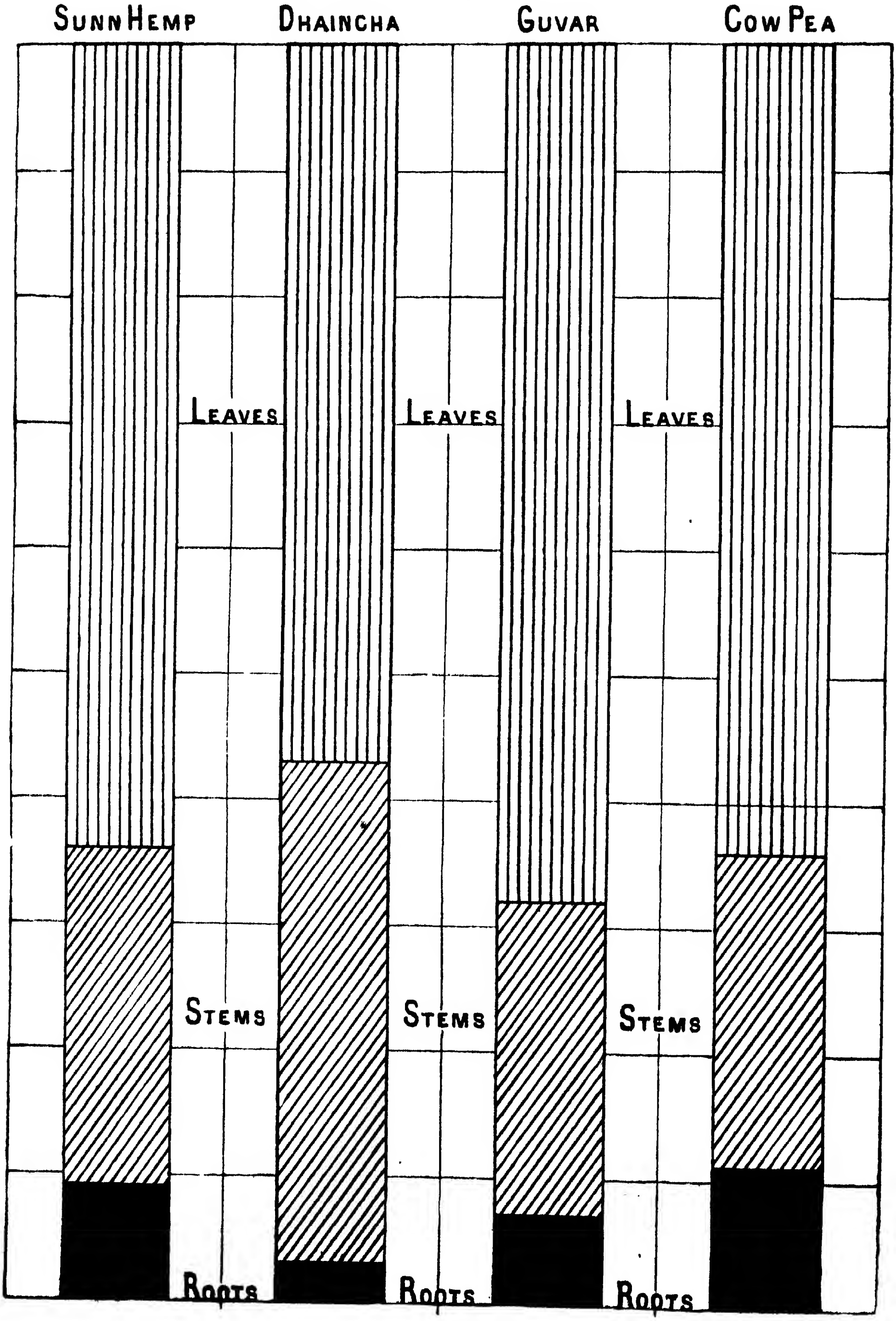
2. The second possibility is that the putrefactive bacteria attacking these succulent tissues multiply to such an extent in the beginning that by their rapid growth they form bacterio-toxins and other products such as indol and skatol, as well as other deleterious substances found by Schreiner, Shorey and others. Though formed in minute quantities under aerobic conditions their presence may retard nitrification.

The next two possibilities presuppose that nitrate accumulation is a resultant of all kinds of bacterial activities going on in the soil, and that nitrate accumulation is not an absolute measure of nitrate formation but the algebraic sum of nitrate formation and nitrate reduction.

3. The lower amount of nitrates formed in the case of succulent plants is due to the fact that destruction of nitrates takes place. The greater number of bacteria that develop on addition of green manures destroy the nitrates that are actually formed, in other words, true denitrification sets in simultaneously with nitrate formation.

4. The further alternative is that some of the putrefactive bacteria assimilate the nitrates formed for their own growth and

NITROGEN CONTENT



convert it into bacterial proteins which become available later on. Without attempting to solve at this stage which or how many of these possibilities are correct we shall take up another question in attempting to answer which we shall have occasion to turn to the discussion of these alternative hypotheses.

A question is often raised, to what part of the plant the benefit of green manure is due, the portion above ground or the portion below ground, *i.e.*, the root residues, and it is suggested that the under-ground portion, *i.e.*, the root residues, is an important asset, and it is further pointed out that if this is so, it is no use burying the whole of the crop of the green manure, but the green manure can be more economically used if the portion above ground is utilized by the farmer or his cattle as feeding stuff and the portion below ground left in the soil to rot. It has been assumed by some writers that the nodule bacteria being associated with the roots and fixing the atmospheric nitrogen there, the roots are likely to contain most of the nitrogen contained in the leguminous plant, this belief being strengthened by the fact that a crop of cereals after a previous leguminous one is always better than that after a previous cereal crop. The only point of difference in the two cases lies in the *roots and stubble* left in the ground, those in the case of leguminous plant containing more nitrogen.

However that may be, the question cannot be answered by analogy because we have not to compare the effect of root residues of a leguminous crop with those of a cereal one. What we have to compare is the effect of the above-ground portion with the under-ground portion of the leguminous plant used as green manure. There can be no doubt as to which of these contains the greater amount of nitrogen. From the various figures of analysis published, it can be seen at a glance that the portion above ground contains nearly three-fourths of the nitrogen contained in the whole plant. There may be exceptions, but for our purpose in this case the four plants under experiment which are commonly used as green manures, *viz.*, sann-hemp, *dhaincha*, *guvar* and cow-pea, this is so. Chart II shows the nitrogen content of leaves, stems and roots from our analyses made for the purpose of experiments described later on.

The only way in which it seems possible that this might be wrong is by having recourse to a supposition that all the nodules which are found on the roots of the *Leguminosæ* do not represent the full number borne by the plant, but a considerably larger number are formed on the roots and get loose from the plants; these subsequently rot in the soil and thus add a considerable amount of nitrogen to the soil. Leaving this more or less far fetched assumption aside, let us consider only the amounts actually found by analysis which show distribution of nitrogen in the proportion stated above. As is already pointed out, however, in the case of soil nitrogen, it is not sufficient merely to consider the quantity of organic nitrogen, but we must also know its ready availability which may differ so much as to make the root residues more valuable than the portion above ground. In order to test this, leaves, stems and roots with nodules in the case of four of the plants were carefully analysed, and portions containing equal amounts of nitrogen at the rate of 30 milligrams nitrogen per 100 grams of soil were added and allowed to nitrify as before and the weekly determinations of ammonia, nitrite and nitrate made. The following two selected charts (Nos. III and IV) illustrate what happens. All the charts represent the same phenomenon and hence those of *dhaincha* and sann-hemp are shown as typical. Another chart (No. V) comparing the nitrifiability of four kinds of leaves is also given which shows differences in the rate of nitrification. There is hardly any choice as regards the nitrifiability of roots and stems of any of these, the amount being so small, but where nodules preponderate as in the case of *dhaincha* there is a slight tendency to larger amounts of nitrates accumulating.

The results so far obtained clearly show that during the first two months of the burial of the green manure, up to which period only results of experiments are available at the time of writing, it is the leaves that are nitrified in the soil, the stems and roots, if anything, inhibiting the nitrate formation or destroying the nitrates formed from leaves, and hence the accumulation of nitrates in the first two months after green-manuring is due to leaves of the plant and not to stems and roots, and, in our opinion, the beneficial effect

CHART III.

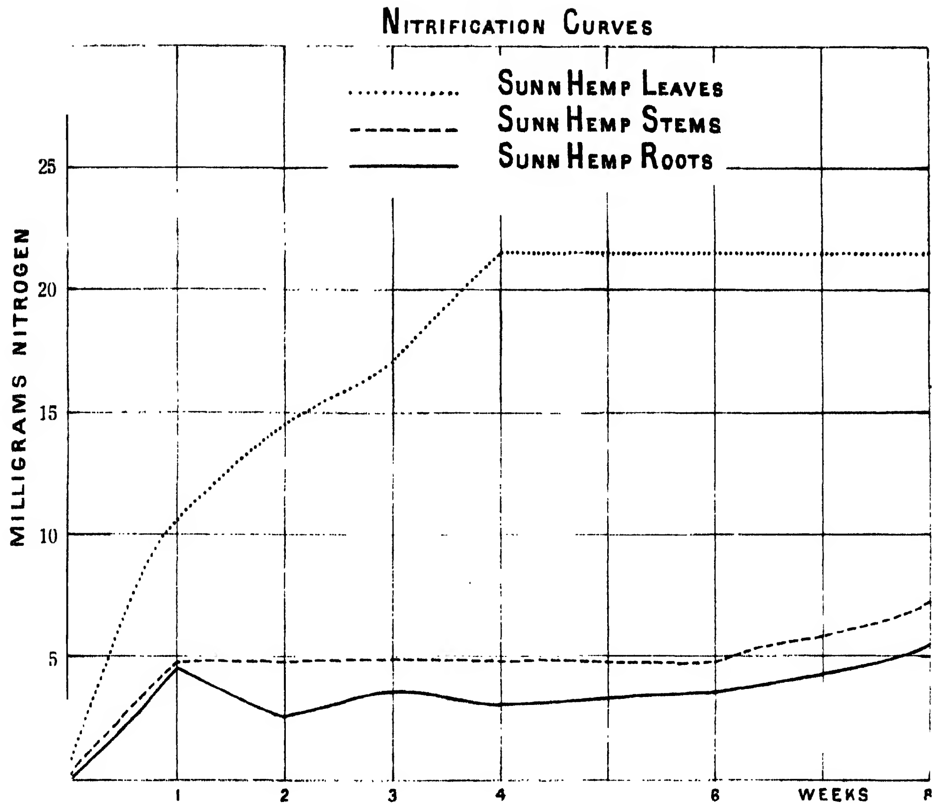
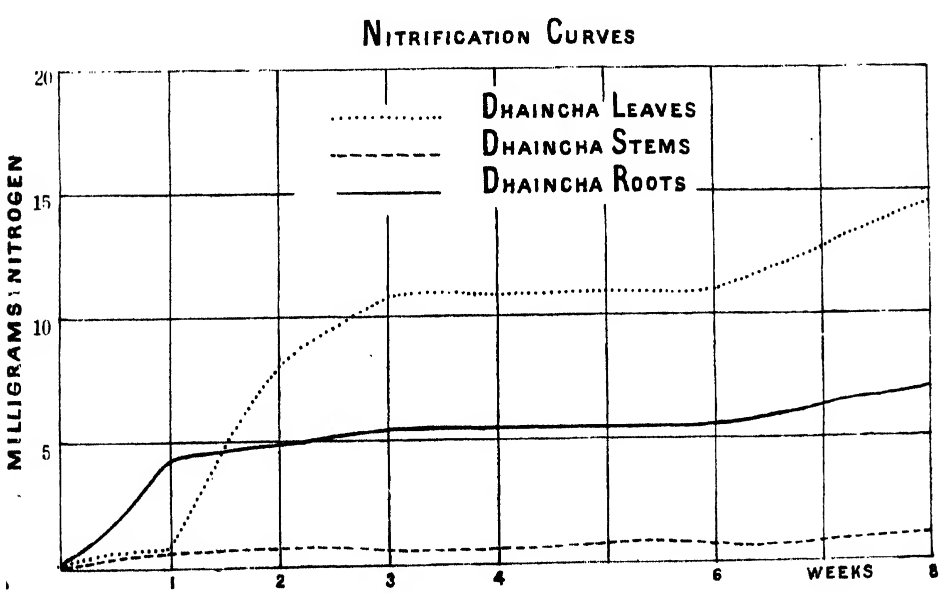
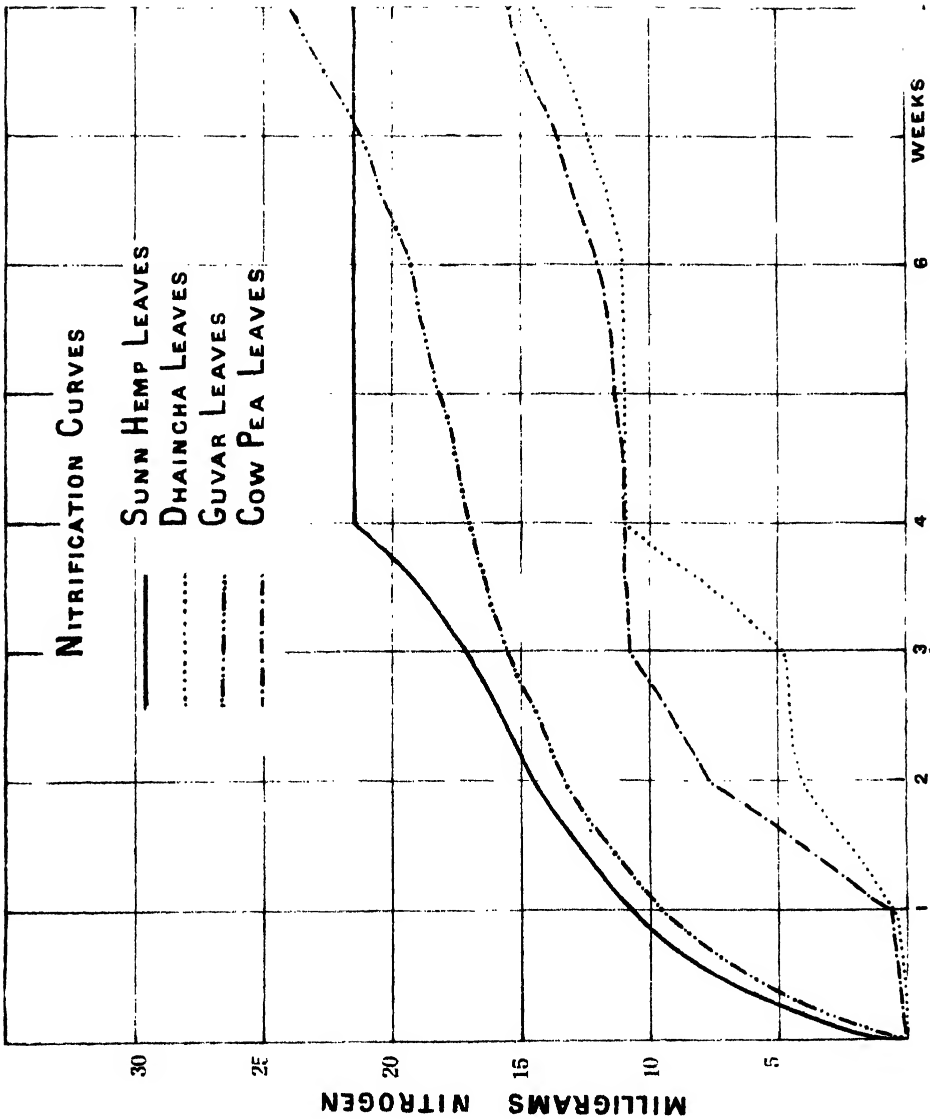


CHART IV.



CHAR



Nitrification Curves
Sunn Hemp Leaves
Dhaincha Leaves
Guvar Leaves
Cow Pea Leaves
Weeks
1
2
3
4
6
Milligrams Nitrogen
30
25
20
15
10
5

of green-manuring on the succeeding crop is to be chiefly attributed to the nitrates derived principally from the nitrogenous material of the leaves of the green manure crop. The quicker rate of nitrification of the nitrogen in leaves and the non-nitrifiability observed in the case of the nitrogenous material in roots and stems further suggests that the beneficial effect which is observed in the cereal crop after a leguminous one as compared with the cereal after a cereal, is also due principally to the nitrogen derived from leaves which are seen fallen on the land carrying a leguminous crop ; only a small part of it can be attributed to root residues.

Besides the benefit derived from the accumulated nitrates by the crop directly following the green manure, sometimes a residual beneficial effect of the green manure is observed on a second crop following in close succession to the first one after green-manuring. This beneficial effect derived by the second crop cannot be reasonably ascribed to nitrates previously accumulated, since the nitrates so accumulated are already used up by the first crop directly following the green manure, and there is nothing left of the green manure in the soil except the undecomposed portion of stems and roots. We have now to account for the residual effect, which is many times observed, as well as that part of the effect of residues in the form of roots of the leguminous crops (apart from that due to the fall of leaves) which is found to benefit the succeeding cereal crop, and we have also to see why the roots and stems are not favourable to nitrate accumulation. These effects may be accounted for in various ways. In order to examine the questions comprehensively, let us see what is likely to happen to the organic material when incorporated in the soil. The process is likely to give rise to a number of changes, any one of which may dominate the rest, depending on the air, water-supply, temperature and the reaction of the soil itself and, as we have seen, ammonification and subsequently nitrification predominates in the first instance at least for eight weeks when the major portion of the nitrates are formed and subsequently removed by the succeeding crops. There are still left in the soil a residual nitrogenous material not nitrified as yet, and such other

structures as cellulose and woody tissues which resist for a long time the action of the soil flora. The possibilities of further action are :

(1) The residual nitrogen, *i.e.*, the un-nitrified nitrogen is likely to be slowly nitrified until finally all the nitrogen is accounted for ; in other words a steady but slow continuation of the nitrification process.

(2) The soil being depleted of its large quantities of nitrates, nitrogen-fixing bacteria, *e.g.*, *Azotobacter Chroococcum* and *Clostridium Pastorianus* and others, are likely to come in action using this cellulose and other soluble carbohydrates that may still be left. The nitrogen accumulated in this way is likely to be nitrified again and prove beneficial to the succeeding crop. Thus the plant residues are likely to prove an indirect source of nitrogen.

(3) If the nitrates formed by the above two processes remain unutilized by a long interval elapsing between the subsequent introduction of another crop they are likely to be assimilated by certain organisms by converting them into bacterial proteins, the necessary conditions being easily decomposable organic matter, *e.g.*, carbohydrates and air.

(4) If by chance the air supply be cut off by water-logging or some such accident the nitrates are likely to be decomposed into either of the following : nitrites, or any of the gases, ammonia, nitrogen, nitrous or nitric oxide.

Of these processes the last is the most harmful and depends upon the cutting of air supply which we need not assume for a normal well drained arable soil. Nitrate assimilation is not so harmful as the disappearance of nitrates in this case is only temporary : the bacterial proteins formed by bacteria are likely to be nitrified again. Of the first two suppositions the second has been studied at Rothamsted and the results published in a paper " Effect of Plant Residues on Nitrogen Fixation " contributed by Hutchinson in a recent number of the *Journal of Agricultural Science* (Vol. IX, No. 1).

A short summary of the conclusions arrived at by the author may be useful in this connection and is therefore given :

"The nitrogen content of sand or soil may be appreciably increased by the activity of Azotobacter when some suitable source of energy is supplied. Sugar and starch are suitable for this purpose but distinct gains of nitrogen have also been obtained by the use of plant residues. Distinct gains of crop resulted from the application of carbonaceous compounds under favourable soil conditions. In addition to the supply of some source of energy, a suitable temperature, the presence of phosphate, and a supply of basic material, such as calcium carbonate, are necessary for the successful operation of nitrogen fixation process.

"Even under the most favourable circumstances for nitrogen fixation, there occurs a period during which adverse processes come into play, and it is not advisable that a crop be introduced before these have run to completion."

These conclusions are based on longer experience and therefore on a firmer basis. Our experiments though not yet completed confirm the conclusion that nitrogen is fixed in soil and in sand with either glucose, sugar or filter paper as the source of energy. We have however found that the nitrogen fixed in this way does not nitrify within four weeks, *i.e.*, no increase in the amount of nitrates already present in the soil is obtained within four weeks. It is under observation whether the nitrogen fixed by the bacteria will be nitrified afterwards and also when it may become available. We have further observed in pot experiments that part of the nitrogen fixed by the nitrogen-fixing bacteria with glucose as the source of energy is in a form capable of being absorbed by plants without the intervention of nitrifying bacteria.

Although it may be taken as definitely proved, therefore, that nitrogen fixation occurs with green manure residues in the soil, it is worth while to examine the cause of the slow nitrifiability of the un-nitrified nitrogenous material as this is likely to throw some light on the non-nitrification of nitrogen in stems and roots. The constitution of the nitrogenous material in question may be assigned as the probable reason of this slow nitrification, each kind of nitrogenous material being assumed to have a different nitrifiability.

Some experiments were, therefore, undertaken on different kinds of nitrogenous materials. The evidence obtained so far does not support the idea of difference in nitrifiability, as none of the substances tested showed any variation from one another in this respect, and unless some substance showing a different nitrifiability is actually found any explanation based on this possibility will be unsupported. Attention was, therefore, next directed to find out whether the non-nitrogenous material in the undecomposed tissue has any influence on nitrification as this undecomposed tissue which does not nitrify quickly is largely composed of cellulose and woody tissue, and as stems and roots which do not nitrify also contain a greater proportion of cellulose and lignin than the more easily nitrified leaves, we proposed to ascertain what effect some of the non-nitrogenous materials have on nitrification. Experiments are still in progress. It may be added that this question is rather important from a biological point of view, as although much work has already been done on the subject by others, yet sometimes definite information is found wanting. Among other substances dealt with, sugar, starch, filter paper, cellulose, straw, sawdust, resin and gums were experimented with. Some of these are likely to be present in succulent tissue, others in the more woody portion. The results obtained so far indicate that when each of these substances is separately added with either ammonium sulphate or oilcake as the nitrifying material to Pusa soil, accumulation of nitrates is effectively checked as compared with the controls.

It is inferred from this that destruction of nitrates takes place in the presence of these substances. To this destruction of nitrates is probably due the adverse effect on plant growth produced by the application of sugar, starch and hay dust in the Rothamsted experiments when a minimum of interval elapsed between the application of these substances and the sowing of the crop.

It is clear from the above experiments that the failure of green manure to nitrify as in the case of tamarind (*Tamarindus indica*) or parts of green manure such as stems and roots in all the four kinds of green manures experimented with may occur under optimum conditions of moisture and temperature and rate of application.

Of the different parts of green manure, leaves nitrify quickly while roots and stems practically do not show any nitrification.

Hence it follows (*a*) that most of the immediate effect of green manures is due to the nitrogen contained in the leaves being quickly nitrified, and also (*b*) that the effect of a leguminous crop on the succeeding cereal crop is due mostly to the fall of leaves from the leguminous crop.

The failure to nitrify so far as ascertained does not depend on the nature of the nitrogenous materials. It is probably due to nitrate reduction occurring in presence of great quantities of non-nitrogenous materials such as cellulose and woody tissue. Whether it is possible to avoid these failures by eliminating the effect of these constituents or these constituents themselves which adversely affect greater fertility by inhibiting nitrification is a subject for further enquiry; but it should be borne in mind that this cellulose and woody tissue is very likely to serve as a source of energy to nitrogen-fixing bacteria such as Azotobacter and thus ultimately prove an indirect source of nitrogen, and to the nitrogen fixed in this way the residual effect of green-manuring and the effect of root residues of the leguminous crop on the succeeding cereal may possibly be ascribed.

The paper was followed by a good discussion, the substance of which is given below:—

Dr. Gilbert J. Fowler.—In my view the author is really measuring in his experiments the resultant of a number of reactions. It is well known that under aerobic conditions the only method by which cellulose is broken down otherwise than by the action of certain moulds, etc., is by the reduction of nitrates. The rapidity of this denitrification would depend, as the author's experiments indicated, on the character of the cellulose present. With a resistant form of cellulose, *e.g.*, the skeleton of leaves, the nitrate formed by oxidation of organic nitrogen might be absorbed by the plant before denitrification could take place. With less resistant celluloses the reverse might be the case. It is worthy of suggestion whether some form of silage of green manures under controlled

conditions, preliminary to their application to the soil, may not tend to nitrogen economy. It may also be pointed out that while the presence of carbohydrate material is favourable to denitrification, it facilitates nitrogen fixation.

All these factors have to be separately considered and, if possible, separately studied.

MR. B. C. BURT.—Some results obtained with leguminous crops grown on drain-gauges at Cawnpore suggested that it might often happen that the effect of the roots of green crops was out of all proportion to the amount of nitrifiable matter that they left in the soil. In these experiments, one gauge carried a crop of sann-hemp (*Crotalaria juncea*) during the monsoon, which was removed green in September and followed by wheat in October, the control gauge was fallow in the rains and carried a wheat crop in the cold weather. Although the addition of organic matter was small, the accumulation of nitrogen in the sann-hemp gauge was most marked. The conditions were admittedly artificial owing to the fact that the false bottoms of the gauges provided for under-aeration as well as ensuring drainage, but the results were suggestive and experiments under field conditions were now in progress.

In respect to green-manuring I deprecate too much limiting of attention to the amount of nitrogen added to the soil by means of green manures. Experience at Cawnpore suggested that the effect of the green manures on the physical texture of the soil was of the greatest importance, whilst, on the other hand, unless drainage and aeration and soil texture generally were right within fairly definite limits, green-manuring was frequently not successful.

MR. R. D. ANSTEAD.—In considering any work on this subject it is always difficult to correctly interpret the results obtained. There are so many factors, some pulling one way and some another—chemical factors, biological factors, climatic factors, physical factors, each having some effect—that it is difficult to grasp what any particular result really means. During this Congress we have also been told of colloidal factors, and now we have a possible inhibiting factor.

It seems to me that what is needed is an attempt to determine the critical 'factors of what must be a complicated reaction or series of reactions and to isolate these, if possible, and determine the effect of each. Only then shall we able to rightly interpret results.

The work which I have been doing for many years leads me to believe that we are apt to bow down too much to the fetish of leguminous green dressings. I find that plants which are non-leguminous, other things being equal, are very often just as good and give quite as good results in rich soils so that it is not entirely the nitrogen content which has to be considered. The great value of the leguminous plant lies in the fact that it can often be grown successfully as a cover crop on a soil poor in organic matter to begin with where in fact it is badly needed, for example on laterite. By means of the bacteria-containing nodules it is able to obtain the nitrogen it requires for its growth from the air. But it must be remembered that there is a great deal of evidence to show that in rich organic soils the leguminous plant does not develop large quantities of nodules, being able to do without the help of the bacteria and to get sufficient nitrogen in the ordinary way. On such soils it comes down to the level of the non-leguminous plant, and this is another factor to be taken into consideration in this work.

A great deal more work remains to be done before any definite pronouncement can be made with safety as to what does or does not happen when organic manures in the form of green dressings are nitrified in any particular type of soil, and I feel that this work should aim at discussing the critical factors and their individual effect.

The whole subject is one which might with advantage be taken up and discussed at the sectional meeting of agricultural chemists such as that to be held shortly at Pusa. Such a meeting might endeavour to collect and summarize the literature on the subject and the work which has already been done, and make definite proposals as to the lines on which such work might be continued in the future with the special points to be solved.

DR. R. N. NORRIS.—At present, in the study of the decomposition of green manures and other organic manures, there is a tendency to limit attention to the nitrification stage which is after all only the end stage of a considerable number of reactions. I think far more work is needed on the preliminary decompositions involved with a view to ascertaining the nature of the intermediate products and the influence of these on fertility, *e.g.*, humus production, solvent action on mineral matters in the soil, etc.

In Madras, where the chief use of green manures is in connection with paddy, the nitrification stage does not occur, as the fermentation takes place under anaerobic conditions. As Harrison and Subramania Aiyer have shown, the influence here is an indirect one largely resulting from the carbohydrate fermentation, the products of which lead ultimately to the aeration of the crop. Hence, work should not be restricted to the nitrogen cycle only as the carbohydrate fermentation may be of equal importance.

What I advocate, therefore, is a systematic bio-chemical study of the fermentation of organic manures by soil bacteria carried out, as far as possible, in a *quantitative* manner and under such varying conditions as may obtain in the soil.

MR. JOSHI replied :—As it would take too long to give a reply in detail to all the questions raised in the discussion I shall refer to only a few. Although a great number of changes are bound to occur on the addition of green manure to the soil, I have chosen nitric nitrogen to represent the difference in decomposition of green manures because addition of nitrogen is one of the important factors involved in green-manuring and nitrates are the end products of a number of changes in the nitrogenous material so added, and also because nitrates, if accumulated in the soil, are likely to have a great influence on the crop immediately succeeding the green manure. As pointed out in my paper, it is not so much the nature of the nitrogenous material that influences the accumulation of nitrates but the presence of carbohydrates, and, I think, it is the quantity of substances like cellulose, lignin, sugars and resin rather than their quality which so affects the ultimate result.

So long as different green manures give rise to different amounts of nitrates, it is not of material importance whether we say that green manures are differently nitrified, or that green manures act as so many sorts of catalytic agents for the nitrification of the inert nitrogen of the soil, as Dr. Mann suggests. In the end, I may say that I have not altogether lost sight of the other questions raised. Experiments are already in progress to solve some of them and others will receive due attention.

As regards two other points raised by Dr. Fowler, I may add that I have already referred in my paper to the question of nitrogen fixation by the carbohydrates which adversely affect nitrate accumulation. The question of "silaging" of green manures has already been worked out and a modified method of green-manuring has been recommended by Mr. Hutchinson in the ***Pusa Research** Institute Bulletin No. 63.*

THE BIOLOGICAL DETERMINATION OF THE RELATIVE AVAILABILITY OF DIFFERENT NITROGNEOUS ORGANIC MANURES IN BLACK COTTON SOIL.

BY

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I. Introduction.

The availability of various manures is a very important problem, as all plants depend upon available food material for their nutrition. Necessary food material will be available only when it is soluble in soil water and thus capable of assimilation by the plants.

In former days when methods of soil bacteriology had not developed, the valuation of organic nitrogenous manures was based mostly on the percentage of nitrogen found by chemical analysis. But just as the nutritive value of various feeding stuffs depends more on their available constituents than the total, so also the real value of an organic nitrogenous manure depends more on its available nitrogen than the total amount shown by analysis. It may also be possible (as in the case of feeding stuffs) that a particular kind of organic manure, though found to be valuable to a particular class of soil, may have an entirely different value when applied to a soil of another type. We shall now consider how the availability of various manures can be estimated by biological methods.

It may be admitted that organic manures, when added to the soil, have to undergo physical, chemical and biological changes

before they reach the plants, and that the last of these changes is probably the most important. Although there are various biological changes to which organic matter is subjected in the soil, the most important is the decomposition of nitrogenous substances. Formation of nitrates is the ultimate end product of this biological process. It is for this reason that we have chosen nitrifiability as a measure of the availability of organic nitrogenous manures.

Lipman and Burges[1] have also emphasized the value of nitrifiability as a standard for comparing organic manures. The method, therefore, which is adopted here to determine the availability of various manures is based chiefly on the determination of nitrites and nitrates formed in the soil at different periods after the addition of the manure to the soil.

The value and necessity of such investigations into the relative availability of various organic manures has been realized by many, and it has also been suggested by Hutchinson[2] that this and other similar lines of work should be undertaken by agricultural bacteriologists. Having given a brief outline of the subject, we shall now turn to the experimental side.

II. Experimental.

The different organic manures employed in this experiment, with their respective organic and nitrate nitrogen percentages, were as follows :—

Number	Name	Total N %	Nitrate N %
1	Karanja cake (*Pongamia glabra*)	4·38	nil
2	Mahua cake (*Bassia latifolia*)	2·55	,,
3	Castor cake (*Ricinus communis*)	3·90	,,
4	Sarson cake (*Brassica napus*)	4·72	,,
5	Tili cake (*Sesamum indicum*)	6·22	,,
6	Undecorticated cotton cake	5·33	,,
7	Tili cake (oil-free)*	6·71	,,

* This cake was employed simply for the sake of comparison. It is not commonly used by the cultivators.

[1] *Cal. Agric. Expt. Station, Bull.* 260.

[2] *Memoirs, Dept. Agric. India, Bacteriological Series*, vol. 1, no. 1.

Sufficient care was taken to use as far as possible materials of approximately the same size by passing the finely ground material through a 1 mm. sieve. Instead of adding a definite and uniform quantity of nitrogen to the soil, a fixed quantity of manure, namely, one per cent. of the weight of the soil, was employed. Had this procedure not been adopted, the quantities of manures employed in the various cases would have been very widely different owing to the varying percentages of nitrogen, thus probably interfering with the soil texture and consequently with nitrification.

The soil employed for this experiment was from the Nagpur Agricultural College Farm. This soil is the common type of ordinary black cotton soil as found over large areas in the Central Provinces and Berar and many parts of the Deccan. Its nature will be seen from the following physical analysis :—

	Per cent.
Clay	45·62
Fine silt	21·82
Silt	10·79
Fine sand	4·23
Coarse sand	6·04
Moisture	6·37
Loss on ignition	5·68
Calcium carbonate	0·10
TOTAL ..	100·65

The soil was sampled in the usual way, and the portion which passed through 1 mm. sieve was used in the experiment.

In the first place determinations of initial moisture, nitrites, nitrates, etc., in the soil were made, the results of which are as follows :—

	Percentages on dry soil
Initial moisture	11·1
Saturation capacity	66·6 (as determined by a soil layer of 1 cm. depth)
Initial ammonia	nil
„ nitrates	Slight traces
„ nitrites	nil
„ nitrogen	0·038

Method of procedure. Soil representing 500 grm. of dry soil was mixed thoroughly with 5 grm. of the manure to be tested,

and sufficient water (about 30 per cent.) was added to bring the soil to the optimum moisture conditions required, *i.e.*, approximately half saturation capacity, allowance being made for the moisture originally contained in the soil. Any loss of moisture due to evaporation was made up every week if found to be more than 1 per cent. of the soil weight. The soil was well mixed up and put into glass jars with tin covers and incubated for a period of 8 weeks at room temperature. As these experiments were carried out during the months of August and September, the room temperature was not generally much lower than 30°C. during daytime. Amounts of ammonia, nitrites and nitrates were determined fortnightly, and only ammonia at the end of the first week. For estimating nitrites, nitrates. etc., soil equal to 100 grm. dry soil was taken out and occasionally shaken with water for half an hour. 100 grm. of soil to 300 c.c. of water were taken, allowance being made for the water already in the moist soil. The whole soil emulsion was then measured, and half of it was filtered through ordinary filter paper, while the remaining half was used for the estimation of ammonia.

In the filtrate nitrites were estimated by the Griess Ilosvay method, and the nitrates by the phenol-di-sulphonic acid method. Colours in both the cases were matched in a standardized Lovibond's tintometer.

For estimation of ammonia, half the soil emulsion was acidulated with hydrochloric acid and left overnight. After the soil had settled down completely, aliquot quantities of the supernatant liquid were distilled with freshly ignited magnesia, and the ammonia was estimated by the usual titration method, N-10 acid and alkali being employed for the titration.

The amounts of ammonia, nitrite and nitrate, as determined by the above-mentioned methods, are given in the table on the next page.

Table showing amounts of nitrogen in milligrams in the form of ammonia, nitrites and nitrates, per 100 grm. of dry soil.

Name of manure	1st week	2nd week				4th week				6th week				8th week			
	N as NH_3	N as NH_3	N as NO_2	N as NO_3	Total % N nitrified	N as NH_3	N as NO_2	N as NO_3	Total % N nitrified	N as NH_3	N as NO_2	N as NO_3	Total % N nitrified	N as NH_3	N as NO_2	N as NO_3	Total % N nitrified
Karanja cake ..	7·90	8·80	traces	0·77	1·75	4·48	5.35	16·01	36·38	1·12	sl. tr.	28·18	64·04	1·12	nil	28·18	64·04
Mahua cake ..	0·50	1·68	nil	nil	0·00	1·12	nil	nil	0·00	0·56	nil	nil	0·00	1·12	,,	nil	0·00
Castor cake ..	9·94	10·08	traces	0·77	1·97	7·28	6·43	6·40	16·39	0·56	,,	28·18	72·25	1·12	,,	25·62	65·69
Sarson cake ..	11·42	9·32	,,	0·77	1·63	5·60	6·85	9·60	20·42	0·56	sl. tr.	25·62	54·51	0·56	,,	25·62	54·51
Tili cake ..	21·40	19·04	0·75	1·02	2·84	10·08	9·85	10·25	16·53	1·12	,,	35·86	57·83	1·12	,,	40·99	66·11
Undecorticated cotton seed cake.	11·80	13·44	1·28	1·54	2·90	3·92	0·76	20·35	38·39	2·80	nil	32·02	60·41	1·68	,,	35·86	67·66
Oil-free *tili* cake	20·92	22·40	0·75	6·40	9·55	14·00	9·42	11·53	17·20	1·68	slight traces	43·55	65·00	1·12	,,	49·95	79·28

The total percentage nitrogen nitrified, referred to in the last column of the above table, includes both nitrite and nitrate nitrogen.

Various facts can be ascertained from the foregoing table, and the results can therefore be individually examined for each manure separately.

Karanja cake. This cake appears to be very susceptible to nitrification. Two important features are noticeable about this manure—one is the absence of such high concentrations of ammonia in the soil as are found with cotton and *tili* cake ; and the other is the rapid formation of nitrates which is not experienced in any of the other manures except cotton cake. In this case as much as 36 per cent. of the nitrogen is converted into the form of nitrates by the end of fourth week as against 16 per cent. with castor and *tili* cakes and 20 per cent. with *sarson* cake.

Mahua cake. This cake seems to be very peculiar in that it is not nitrified at all even during a period of 8 weeks. The nitrogen in this manure appears to be resistant to the action of soil micro-organisms, thus totally excluding *mahua* cake from consideration as an active organic manure. Ammoniacal decomposition also seems to be tardy in operation in this case, and it amounts to practically nothing even after a period of 8 weeks. In order to further elucidate this problem of ammoniacal decomposition, a special experiment was conducted as follows :—

A quantity of *mahua* cake, containing 60 milligramms nitrogen, was added to a solution of sodium chloride before or after the various treatments as detailed below, and the whole was then sterilized. The mixture was then inoculated with 1 grm. of black cotton soil and incubated for a period of 8 days. Afterwards the amount of ammonia formed was determined by the usual magnesia method. In order to compare the results of this experiment, another set of solutions containing *tili* cake instead of *mahua* cake was employed.

The treatment of the cake was as follows :—

1. *Mahua* cake (containing 60 mg. N), plus 100 c.c. 0·5 per cent. sodium chloride solution, plus 1 grm. black cotton soil (incubated without any treatment).

2. *Mahua* cake as above, but heated up to 120°C. dry heat in a sterile flask, plus 100 c.c. sterile 0·5 per cent. sodium chloride solution added afterwards, plus 1 grm. black cotton soil.

3. *Mahua* cake plus 100 c.c. 0·5 per cent. sodium chloride solution (both sterilized at 130°C. moist heat for 15 minutes) and then inoculated with 1 grm. black cotton soil.

The amounts of ammonia formed after a period of 8 days out of 60 mg. nitrogen originally contained in the material were as follows :—

	Mahua cake	*Tili* cake
1.	0·07 mg.	25·90 mg.
2.	0·42 ,,	29·40 ,,
3.	0·42 ,,	30·10 ,,

From the above experiment, it is seen that the ammonification of *mahua* cake does not take place at all quickly, and at the same time artificial treatment, such as dry and moist heat, does not help it in any way. Hence nitrification appears to be impossible within a period of at least 8 weeks. Whether it is nitrified at all or not after a very long period is not yet ascertained, but, as a manure, *mahua* cake cannot be classed with the other commonly occurring cakes.

Why this material should not readily decompose in the soil, and what treatment is possible to bring it into a suitable form for quick bacterial action, are problems under investigation.

Castor cake. This cake appears to be as quickly decomposing a manure as *karanja* cake, although in the beginning a lower percentage of nitrates was found.

Sarson cake. This cake seems to be the slowest in decomposition of all except *mahua*, at least so far as its nitrifiability in black cotton soil is a guide.

Tili cake. This is more or less on the same level as *karanja*, castor and cotton cakes as regards the total percentage of nitrogen nitrified, but it is not as rapidly nitrifiable as *karanja* and cotton cakes. Accumulation of ammonia seems to be higher during the first 4 weeks in this case than with *karanja* and cotton cakes.

Cotton cake. This seems to be more or less similar to *karanja* cake in every respect.

Tili cake (oil-free). Considering the total percentage of nitrogen nitrified, this cake is the best of all. High concentration of ammonia and nitrites, however, takes place with oil-free *tili* cake to a

greater extent than with the other manures under investigation. The total quantity of nitrogen nitrified goes as high as 79 per cent. as against 0 to 67 per cent. in other cases. The fact that the removal of oil from oilcake increases the rate of nitrification has been observed on other occasions also. Whether the costly process of removing oil from oilcakes would in the long run be economical merely from a manurial point of view is doubtful, particularly when it is considered that cakes from hydraulic presses do not contain sufficient oil to seriously retard decomposition. Machine-pressed cakes for manurial purposes will, however, be distinctly more advantageous than those obtained from a country *ghani* (mill), as the oil is far more completely removed in the case of the former.

III. Summary.

1. The relative availabilities of the common oilcakes used as manure have been determined by considering the rate at which the nitrogen they contain undergoes bacterial transformation.

2. The soil used in the experiments was the common black cotton soil of the Deccan.

3. Excluding oil-free *tili* cake, *karanja* and cotton cakes appear to be by far the most quickly available, and castor cake is not much inferior to them.

4. *Tili* cake is not quite so active, although the nitrogen ultimately nitrified compares favourably with that of other cakes.

5. Of the various manures used in this experiment, with the exception of *mahua* cake, *sarson* cake is the slowest so far as its nitrifiability in black cotton soil is concerned.

6. The nitrogen in *mahua* cake is neither ammonified nor nitrified to any appreciable extent during a period of 8 weeks.

A STUDY OF THE CONDITIONS UNDER WHICH WATER OF TIDAL SALINE CREEKS IS UTILIZED FOR CROP PRODUCTION IN KONKAN.

BY

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A PRACTICE of using waters of the saline river creeks for growing some of the commonly cultivated crops has come to the notice of the writer in Konkan.

With a view to clearly understand the conditions under which this is done, and thus to find out the possibilities for the extension of the practice, a detailed study of the question was taken up. The results which the enquiry has led to are of some scientific interest, since they seem to take us some way further in our existing knowledge about the resistance of agricultural plants to the salinity in the water they have to live on ; besides, a good scope is also indicated for the extension of the practice to newer areas, where it is not known at present, but where the conditions may be found suitable. The object of this paper is to record the information which has been collected and the findings which have been arrived at on the subject.

The practice attracted my attention first early in the year 1916, when I was touring along the Savitri river creek (Bankot-Mahad creek in the Kolaba District of the Konkan), where successful crops of brinjal (*Solanum melongena*) were seen growing with the exclusive help of the water from the section of the creek between

Dasgaon and Mahad, *i.e.*, about 20 miles higher up in the interior from the mouth of the river where it joins the Arabian Sea. Enquiries—agricultural, chemical and geographical—have since been in progress, and it has been possible to-day to fairly define the conditions under which the practice of growing some crops with the help of the saline water is followed.

Description of the tract under observation in respect to its creeks and creek sides.

Before describing the conditions in detail, it would be desirable to briefly summarize the physical features of the area under enquiry, especially in relation to its rivers and creeks. The study of the question has so far been confined to Konkan, *i.e.*, that part of the Bombay Presidency stretching along between the west coast of the Arabian Sea and the Western Ghats. and comprising of the four districts of Thana, Kolaba, Ratnagiri, and Kanara (excluding the up-ghat portion). It receives heavy storms of rain measuring 100 inches or more in a very short period of four months of June to September. It is hilly and much traversed by rivers of more or less size, which, rising in the Ghats, take their course more or less westwards across the breadth until they join the Arabian Sea, by short drainage channels which form the tributaries of the large rivers and by backwater channels. The water from the sea rises back in these water lines at high tides to more or less distances according to the length and the fall of the courses, in large rivers going as back as 25 to 35 miles from the sea ; above this point they are sweet water streams, which greatly diminish in their size, in some cases almost to nil, as the fair season advances. For about 15 to 20 miles from their mouths the creeks wind between low-lying plains on either side, which are permanent marshes or reclaimed salt rice lands, in the comparatively flat and open country of the Thana, Kolaba and Kanara districts, or between deep gorges formed by the slopes of narrow valleys of the Ratnagiri District. Higher up, towards the high tide water limit and above, however, their courses in both cases lie between steep banks five to ten feet or more above the water-level, which stretch more or less wide and flat, or gently

sloping if at all away from the bank; these belts of upland get submerged at high floods of the river during the rainy season and receive deposits of fine silt; these are called *malkhandis* (*mal* silt, *khand* piece), and are usually deep, fertile and retentive of moisture and grow fine dry crops of *tur* (*Cajanus indicus*) and sesamum (*Sesamum indicum*) in the *rabi* (winter) season; on sufficiently high banks which are less liable to submersion, even *kharif* crops like *nagli* (*Eleusine coracana*), *vari* (*Panicum miliaceum*), and niger seed (*Guizotia abyssinica*) are grown.

Factors determining the successful growth of certain crops with saline waters.

Degree of salinity which the crops cultivated can withstand. Now, coming to the describing of the determining factors, the first that may be considered is the degree of salinity of the water which is actually being successfully used for the growing of certain crops. It is the common belief that the waters of the creeks, as described above, are quite sweet up to within a few miles to the sea, during the monsoon, owing to the very large volumes of sweet water from the characteristic heavy rains of Konkan flowing into them, and after the monsoon they acquire more and more salinity in stages as the fair season advances and as the volume of sweet water diminishes, until at last they are considered to be quite unfit by about the middle or the end of February. The character of the past rainy season is believed to advance or retard the acquisition of salinity; thus a year of deficient rainfall as the current (1918) year, or even too early cessation of rain is asserted to bring on salinity earlier. In order to verify this belief and to measure it in definite terms, samples of waters taken at the time of each watering that was given to a crop of brinjal (*Solanum melongena*) throughout its growing period from the creek of the river Amba near Nagothna (Kolaba District) were analysed for their salt contents through the kindness of Dr. H. H. Mann, Agricultural Chemist to the Government of Bombay; the results are set out in the following table :—

Statement showing the contents of salts in tidal creek waters in Konkan.

Description of the sample	Total salts	Containing						Remarks
		Sodium chloride	Calcium carbonate	Calcium sulphate	Magnesium sulphate	Magnesium chloride	Magnesium carbonate	
			Parts per	100,000	of water			
Water from creek near Mahad on which crops grow, taken on 11- 1-1917	52·00	36·96	5·81	..	..	..	..	Excellent irrigation water (Dr. H. H. Mann).
Water from creek near Bandsa (Nagothna) 11- 1-1917	764·00	612·15	15·49	..	..	..	..	Useless (Dr. H. H. Mann).
Do. Nagothna .. 17-12-1917	52·00	24·42	9·68	3·06	0·37	8·32	..	
Do. ,, .. 27-12-1917	30·00	3·39	11·62	0·34	6·90	6·64	..	
Do. ,, .. 31-12-1917	112·00	69·46	11·62	0·34	7·90	9·29	..	
Do. ,, .. 5- 1-1918	118·00	70·69	10·00	..	8·20	12·19	0·28	
Do. ,, .. 9- 1-1918	174·00	111·11	14·00	.	13·32	15·40	..	
Do. ,, .. 17- 1-1918	878·00	673·85	28·00	..	4·10	65·06	32·26	
Do. ,, .. 25- 1-1918	820·00	567·77	12·42	29·39	44·87	78·47	..	
Do. ,, .. 2- 2-1918	836·00	582·84	12·42	21·14	56·17	66·19	..	
Do. ,, .. 10- 2-1918	840·00	646·55	12·42	15·70	59·92	56·69	..	
Do. ,, .. 24- 2-1918	856·00	634·19	20·70	15·30	69·05	66·70	..	
Do. ,, .. 28- 2-1918	2120·00	1442·51	20·70	80·58	114·45	196·08	..	
Do. ,, . 15- 3-1918	2732·00	1906·92	18·63	68·65	180·05	203·28	..	
Sample of *salt water* from rice plots, Larkhana, Sind, which is supposed to be the strongest that rice crop can withstand (October 1918).. ..	940	742·50	5·17	63·68	43·56	..	Potassium chloride.	Kindly supplied by Mr. V. A. Tamhane, Acting Agricultural Chemist to the Government of Bombay.
AVERAGE SEA-WATER ..	3500	2653	..	161	196	318	129	

It will be seen that the above analytical results are sufficient to bear out the popular belief and clearly establish that up to the end of December creek waters from the sections where they were taken, *i.e.*, about 27 miles away from the sea and about 7 miles lower than the highest limit of tide water, are tolerably sweet and fit to sustain crop growth, and that after that time they get more saline and remain so for two months, while by the end of February the salinity suddenly increases to as much as about three-fourths of the salinity of the average sea-water. Another noteworthy point that can be deduced is that the salinity from the middle of January onwards is more than the limit which might be ordinarily considered as the strongest that ordinary crops or even rice, the most resistant of the crops known, were so long known to withstand. The enquiry, however, reveals that certain crops as are at present cultivated can, as is actually the case, withstand even larger degrees of salinity.

Next, in order to find out how far and under what physical or other conditions and circumstances similar practices do or do not obtain on creeks of the four Konkan districts, some typical and important creeks representative of each of the four districts were surveyed. In the Thana and Kanara districts the practice is unknown; the reason given is the ignorance of how such a thing could be possible. In the Kolaba District, on the Revdanda-Roha creek, the cultivators do not take any crops, though they know the fact that their neighbours at Nagothna on the Dharamtar creek do use the saline water for raising certain crops. But on the remaining important creeks of the Kolaba District, and almost all the big creeks of the Ratnagiri District, the practice appears to be generally known and in vogue in particular sections of the creeks as described hereafter.

Parts of the creek which are considered and found suitable. The distance from the sea to which the high tide reaches on large creeks in Konkan is generally 25 to 35 miles as has already been said above. It was uniformly observed on all creeks that using of the saline water for crop production is generally confined to the large creeks and its tributaries, and to such sections on them as lie

within the last 8 or 10 miles of the tidal limit along which there are banks, with deep, well-drained soils, and high enough as not to be submerged by tidal waters, but not too high (up to about 10 feet) to make water lifting prohibitively costly.

The reasons for the absence of any similar cultivation of crops with saline waters along the lower parts of the creeks are stated to be two :—The first and the most common and likely is that the waters in the lower sections as the sea is approached get more and more saline and that too earlier than at the sweet water ends. Secondly, along the low-lying creek side plains of Thana and Kolaba creeks, there are no suitable lands close by the waters, on account of their being either marshes or reclaimed salt rice lands which are believed to be containing already an excess quantity of salt. Along the creeks in the Ratnagiri District, however, the second condition does not prevail, the hill slopes edging the creek waters and affording at least some good land fit for cultivation ; but even here no saline water cultivation is thought of.

Both these points require further investigation by actual analyses and trials.

Crop found suitable. Brinjal (*Solanum melongena*) is by far the commonest crop which is cultivated under the above conditions. Chillies (*Capsicum frutescens*) is the next one in importance, not being however considered as resistant to salt as brinjal ; castor (*Ricinus communis*), sweet potatoes (*Ipomea batatas*) and maize (*Zea Mays*) sometimes are seen to occupy the borders, odd corners or as a sprinkling in the main crops of brinjals and chillies. There are no special varieties of these which are recognized as particularly suitable for cultivation on saline water. In Kanara District, a solitary instance of the creek water being used for irrigating young coconut seedlings in the months of April and May without any apparent harm to them was noticed at Hedge in the Kumta taluka.

Method of cultivation. Sites having suitable soil and level fields at points where they would be edging the water of the creek and the lift would be small are usually selected for cultivation, so that the lift and lead of the water would be as little as possible. In October, after the monsoon rains cease, the soil is broken up

by a plough and further pulverized by the breaking of clods with mallets, and is thus thoroughly prepared to a depth of 6 to 8 inches. If there be not enough moisture in the soil, it is wetted by pouring water in small patches at from 2 to 3 feet apart each way. In this wet soil holes 3″ to 4″ deep are bored with a peg or a stick, and seedlings are inserted in these holes and soil pressed over. No manure is generally used, but occasionally those who have any farmyard manure to spare do give it to each plant at the time of planting; some people put water mixed with fresh cattle dung in the holes before planting; another dose of farmyard manure is again given by some if available at the time of earthing up. The crops are not, however, taken continuously in one and the same place for more than one to three years according as they are nearer to, or further from, the sea, as it is supposed that the soil becomes salt sick after that period.

Irrigation. Irrigation is begun and continued as required. For the first week after transplanting, hand watering is done twice a day, after which it is done once a day for about a week more, and on alternate days for another week. It is considered necessary by practical men that the water given to the newly transplanted seedlings must be sweet until they take root and establish; ordinarily the water in the sections of the creeks where the cultivation is practised, is sweet at the time of transplanting in the middle of October, but if for any reasons it should happen otherwise, sweet water from some other source has to be provided.

If the soil is fairly retentive, no water is given until the flowers begin to appear by the end of November as on the Vashisti river (Chiplun, District Ratnagiri) creek. After this some kind of water lift is set up and irrigation given every four to six days or more up to the middle of February, and thereafter for a month more at an interval of about a fortnight. In some cases it is also found that plants are watered on four consecutive days from the 10th to the 14th of each lunar half, the reasons being that more labour is required from the 4th to 9th for lifting the water, which rises but very moderately on these days, and on the 15th, 1st, and 2nd there is more salinity in the water.

After this, the creek water getting too saline, watering is stopped and the plants are allowed to grow on residual soil moisture, on which they thrive and continue to bear till the end of the hot weather; cases have also been noticed where brinjal plants, after thus surviving through the hot weather, take on fresh vigour on the commencement of the monsoon, and continue to bear until they are killed by the floods.

The extent of the salinity which the creek waters acquire at different times of the season and at points where crops are grown can be seen from the statement given above.

In the latter part of the season a distinct incrustation of salt is visible on the surface of the land.

The time of irrigation is generally chosen at the high tide, when the level of the water in the creek naturally rises and the lift and the lead are thereby reduced. No difference, however, is recognized between the high tide and the low tide water, as regards its suitability or otherwise for crop growing.

The water lift most commonly used is *Okti*, the counterpoise bucket lift worked by hand, though on one creek in the Ratnagiri District Persian wheel is also used; where the area to be cultivated is small, watering by *gharas* (earthen vessels) is resorted to.

Further care and outturns, etc. The only other care that the crop requires besides the above is earthing up, fencing, watering and harvesting. The first and the heaviest picking of fruits is obtained in the months of January, February and March, yielding moderate pickings; from April onwards only small pickings are obtained, the fruit borne diminishing in size and contracting in the case of brinjals an acrid taste. The outturns are by no means less than those obtained under ordinary methods of cultivation with sweet water; the quality is also said to be as good as that from the sweet water.

Conclusions.

Creek waters are mostly sweet during the monsoon, are tolerably so till the end of December, and after that time this salinity increases to an extent which would have so long been considered as unfit

for the ordinary agricultural plants, but which it is found can safely be used for growing very successful crops of brinjal and chillies till the end of February. After this they get too saline to be used without harming the plants watered.

2. According to the information which has been made available so far, it is only in the last eight to ten miles below the point to which the high tide reaches that such crops can be grown.

3. There are yet many situations in the Ratnagiri and Kolaba districts where the practice is already known, and in the Thana and Kanara districts where the practice is altogether unknown, in which the cultivation can be extended and introduced with great advantage. The crop of chillies, which can be turned into a durable product, and which is an article of every-day diet of the Indians, presents a better scope than brinjal, which is of a perishable nature. Perhaps other parts of India and those of the world where conditions may be suitable may benefit by the information recorded in this paper.

4. It might be ascertained by analysis and actual trials if creek water in the lower sections cannot similarly be used for growing any crops. Similarly, several other agricultural plants, especially those which are known to be salt-resisting to some extent, might be experimented with, with a view to find if any new or more profitable crops cannot be added to the present list. This would be made a subject of future study.

A PRELIMINARY NOTE ON SOME NEW FACTORS AFFECTING THE HARDNESS OF *GUR* OR CRUDE SUGAR.

BY

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It is a matter of common knowledge that hardness in *gur* (crude sugar) is an essential factor in the successful storage of it through the monsoon.

It is often pointed out that the factors affecting this hardness or keeping quality arise mainly in the *gural* (boiling) house and they are attributed to one or the other of the following :-

(1) Ripeness of the cane.

(2) Milling, clarification of the juice and its boiling.

(3) Cleanliness in the boiling house.

(4) Lodging of the canes.

But from observations made in the Gokak-Hukeri tract of the Belgaum District, I have come to the conclusion that these are not *all* the factors, but there are some more which are equally, if not more, important.

In the tract referred to above, there has been a longstanding belief among cultivators that the hardness or keeping quality of *gur* is dependent on the conditions of soil and water, over and above the essentials in the boiling house. This idea seems to be equally prevalent among the merchants who store the product. By experience they are able to give a list of the places which are noted for this good quality in the *gur* as well as of such localities which

do not produce the right kind though the details of cultivation, manuring and manufacture are practically the same.

With a view to rectify the defect and to meet demands from cultivators, expert *gur* boilers were sent, from time to time, to these places, but the measure of success attained was small.

I had, therefore, to investigate into the subject on a systematic basis. The lines on which I proceeded and the details I collected can best be seen from the statement attached (Appendix I).

In making the tests, I have, as far as possible, avoided the lodged plots and tried to obtain uniformity in the other factors hitherto supposed to affect the glucose ratio and hardness, such as ripeness, manuring, boiling, etc. But it is interesting to note from the statement that, wherever there has been a variation in the soil or water, the hardness has been affected.

In fact, grey soil and brackish water tend to make the *gur* soft and fluid. In one instance, *viz.*, test No. 1 in the statement, brackish water from a well was used for irrigating the sugarcane crop and the *gur* turned out was soft and sweaty. But during the year of my enquiry, sweet water was available during nine months and the resulting *gur* was of better quality.

All these data, I think, should prove that soil and water have also an important bearing on the hard formation and keeping quality of the *gur*.

That salts enter into the composition of *gur* in varying proportions, there is clear evidence to prove from the chemical analysis. The salinity is distinctly marked even to the taste—some *gur* tasting very sweet, others saline. It is the salt in the brackish water and grey soils that must be responsible for the mischief. Whether it is the intrinsic hygroscopicity of the salts that affects the hardness or whether any change is brought about in the glucose ratio of the *gur* has yet to be studied.

To corroborate my observations in the field, I had samples of *gur*, soil and water sent for analysis to the Agricultural Chemist, Poona; his letter and the results of analysis are quoted below (Appendices II, V and VI).

As the Acting Agricultural Chemist remarks, no doubt, a larger number of samples are required to come to a final decision. However his results of analyses of the few samples sent indicate that waters used for irrigation contained varying proportions of alkalinity which are paralleled in a more or less similar ratio by the composition of the resulting *gurs* as well as their hardness.

Again, if we look into the glucose ratios of the bad, sticky samples analysed, they are not bad enough to make an ordinary *gur* very soft. But, as these samples are very soft and sticky, the argument goes to support my observations.

In conclusion, I must admit that there are shortcomings in my paper and I am aware of them. For instance, the Brix readings recorded (Appendix I) cannot be wholly reliable unless the purity of the juice is ascertained. But these and similar defects I could not help for want of a laboratory on the farm.

It is my intention, however, to tackle the subject more soundly next year and to present a complete paper.

APPEN

Statement showing the details of information collected in connection with the Taluka, Bel

No. of enquiry	Survey No.	Name of village	Kind of soil	Kind of manure used for the sugarcane crop: Farm-yard manure	Sheep-folding	Top-dressing	Water used for irrigating the sugarcane crop: Sweet	Saline	Date of planting the sugar-cane	Date of harvesting the sugar-cane
1	2	3	4	5	6	7	8	9	10	11
1	69	Ammangi ..	Light red coloured	Farm-yard manure.	Sheep folding.	...	... ..	Brackish	5 3-17	7-3-18
2	68	" ..	Grey coloured	"	"	...	......	Very brackish	"	12-3-18
3	262	" ...	Reddish brown	"	.	...	Very sweet	......	"	14-3-18
4	16	Masarguppi ...	"	..	"	...	"	.. ..	8-3 17	22-3-18
5	1	" ...	"	..	..	...	"	.	10-3-17	20-3-18
6	9	" ...	Black grey	..	..	...	"	.....	17 3-17	22-3 18
7	360	Mannolli ...	Light grey	..	..	...	Sweet	. ..	10-3-17	25-3-18
8	377	" .	Black	..	..	...	Very sweet	.. .	15-3-17	22-3-18
9	375	" ...	"	..	.	..	"	....	"	"
10	389	Nerli ...	"	..	"	...	"	.. ...	8-3-17	4-4-18
11	179	" ..	"	..	"	...	"	......	"	28-3-18
12	19	" ...	Light black	..	"	...	......	Brackish	29-3-17	26-3-18
13	14	.. ...	"	..	..	Oil-cake and Am. sulphate	Sweet	... ..	30-3-17	28-3-18
14	14	" ...	Black grey	"	..	...	"	......	"	30-3 18
15	17	" ...	"	..	..	...	"	.. ...	"	28-3-18
16	283	Mannolli ..	Black	"	..	...	"	......	4-4-17	15-3-18
17	288	" ..	Medium black	..	..	...	......	Brackish	8-4-17	4-4-18
18	108	Ammangi ..	Black	"	..	...	Very sweet	......	28-3-17	27-3 18
19	110	" ...	"	..	..	..	Sweet		25-3-17	22-3-18
20	55	Nerli ...	"	"	..	...	Very sweet	... ..	15-3-17	23-2-18
21	99	Hebal ...	Sandy	"	"	...	"	.....	24-3 17	25-2-18
22	182	Nerli ...	Black	..	"		"	......	24-3-17	"
23	183	Ammangi ...	"	"	..	...	"	......	9-3-17	24-2-18
24	119	Gotar ...	Light black or grey black	..	"	..	Sweet	......	17-3-17	4-3-18
25	113	" ...	Black	..	"	...	Very sweet	......	10-3-17	5-3-18
26	100	Hebal ...	Black grey	..	"	. .	......	Brackish	24-3-17	3-3-18
27	3	Kochri ..	Brown black	..	"	..	Very sweet	......	8-3-17	25-2-18
28	25	Gawnal ...	Black	..	"	...	Sweet	......	22-2-17	12-2-18
29	38	" ...	Grey black	"	..	..	"	......	"	15-2-18
30	144	Gotur ...	Black	..	"	...	..	... .	8-3-17	14-2-18
31	42	Kochri ...	"	..	"	...	"	. ...	"	16-2-18
32	46	" ...	Alluvial	..	"	...	"	......	7-3-17	18-2-18
33	39	" ...	Black	..	..	...	Very sweet	......	21-2-17	12-2-18
34	32	Gawnal ...	"	"	"	...	"	......	25-2-17	19-2-18
35	45	" ...	"	"	"	...	"	......	28-2-17	"

DIX I.

study of the causes affecting the keeping quality of Gur *in parts of the Hukeri gaum District.*

Condition of the crop at time of harvest	Brix reading corrected	Temperature recorded at the time of striking the boiling pan	Remarks about the cleanliness in the boiling or *gural* house	Kind of fuel used	Colour of *gur*	Reputation for the hardness or keeping quality of *gur* in the locality
12	13	14	15	16	17	18
Slightly lodged	17	120° Centigrade	Fair	Dried stalks of *tūr* and chillies and megass	Black	Usually the *gur* from this field is soft but only this year on account of the crop receiving sweet water from a stream for 9 months, the *gur* is fairly good.
"	16·0	122°	..		"	Soft and sweating.
Standing	18·0	120°	..		Red yellow	Good.
"	16·0	122°	..		Green red	"
"	17·5	120°	.		Red yellow	"
Slightly lodged	16·5	120°	..		Greenish	Good but sweating in the rains.
Standing	17·0	121°	.		Brown	"
Slightly lodged	16·5	120°	..		Red yellow	Very good.
Standing	17·5	120°	"		"	"
Slightly lodged	15·0	120°	..		Reddish	Fairly good.
Standing	18·5	120°	..		Red yellow	Very good.
Slightly lodged	15·5	122°	..		Black	Soft and sweating.
Standing	17·5	120°	.		Red brown	Fair but sweating in the monsoons.
"	16·0	122°	..		Black soft	Soft and sweating.
"	16·5	120°	..		Greenish black	Fairly good in the fair season.
"	15·5	120°	"		Red brown	Fairly good.
"	16·5	122°	..		Green black	Soft and sweating.
"	17·5	120°	..		Green red	Good.
"	17·5	120°	..		Green yellow	Very good and heavy.
Lodged	16·0	121°	"		Brown black	Fairly good but sweating in the monsoons.
Standing	15·5	119°	"		Green yellow	Very good and heavy.
"	18·0	119°	..		Yellowish green	"
"	17·5	119°	..		"	"
Slightly lodged	15·5	121°	..		Brown black	Fairly good but sweating in the rains.
Standing	15·5	119°	"		Reddish green	Fairly good and heavy.
"	15·5	121°	"		Brown black	Bad.
"	17·5	119°	"		Reddish yellow	Very good and heavy.
Lodged in a few places	15·5	Not recorded	"		Yellow red	Very good.
Standing	15·0	"	"		Red brown	Good but sweating in the monsoons.
"	15·0	"	"		Yellow	Fairly good.
"	17·5	"	"		Red brown	"
"	18·5	"	"		Green yellow	Very good and heavy.
Lodged	14·0	"	"		"	Very good for keeping but not heavy.
Standing	16·5	"	"		Green red	Very good.
"	16·5	"	"		Red brown	Fair.

APPENDIX II.

Analysis of water samples used for irrigation in the case of the Gurs *shown in Appendix III.*

	Water No. 1	Water No. 2	Water No. 3	Water Nos. 4 and 5
Total salts	40·000	100·00	92·00	These were lost on way.
Containing :—				
Calcium carbonate	14·00	18·00	26·00	
Magnesium carbonate ..	9·08	19·74	2·48	
Magnesium sulphate	...	7·17	12·30	
Magnesium chloride	...	6·37	20·25	
Sodium bicarbonate	5·32	...	...	
Sodium sulphate	2·44	...		
Sodium chloride	4·52	43·06	7·47	

N. B.—The Serial Nos. correspond to those in Appendix III.

APPENDIX III.

Analysis of samples of different kinds of Gurs.

	Gur No. 1	*Gur* No. 2	*Gur* No. 3	*Gur* No. 4	*Gur* No. 5
	Solid lighter yellow	Soft and sticky dark black	Sticky semi-solid dark to red	Solid and hard darker	Solid and hard darker
	%	%	%	%	%
Moisture	4·88	6·58	7·66	3·36	3·88
*Ash	1·08	1·46	1·54	1·54	1·58
Glucose	7·53	9·60	7·36	4·73	5·09
Sucrose	77·90	79·04	75·18	87·38	84·94
Glucose ratio .. .	9·66	12·14	9·78	5·41	5·99
Alkalinity calculated as :—					
Sodium carbonate ...	0·010	0·042	0·063	nil	0·010
Carbonate as CO_2 ...	0·147	0·171	0·110	0·100	0·183
Chlorine	0·084	0·252	0·224	0·112	0·112
Equivalent to sodium chloride	0·138	0·416	0·369	0·185	0·185

* Containing in the water solution.

N.B.—These Nos. correspond to those in Appendices II, IV & V.

APPENDIX IV.

Statement giving the details of information about the Gur *samples analysed in Appendix III.*

	Nature of soil on which it is produced	Nature of water used for irrigation	Local reputation about the keeping quality
Gur No. 1* ..	Medium black	Sweet	Hard and keeping well.
,, No. 2* ..	Grey	Brackish	Bad and sweating.
,, No. 3* ..	,,	Slightly brackish	Not good.
,, No. 4* ...	Brown red	Very sweet	Hard, heavy and keeping quality excellent.
,, No. 5* ...	Light grey	,,	Fairly hard and keeping.

* There was practically no difference either in the condition or cultivation of the crop or manufacture of *gur* or manuring.

N.B.—The Serial Nos. correspond to those given in Appendix III.

APPENDIX V.

Analysis of soil samples relating to the Gurs *shown in Appendix III.*

	Soil No. 1		Soil No. 2		Soil No. 3		Soil No. 4		Soil No. 5	
	Surface soil	Sub-soil	Surface soil	Sub-soil	Surface soil	Sub-soil	Surface soil	Sub-soil	ace soil	Sub-soi
	%	%	%	%	%	%	%	%	%	%
Total soluble salts ...	0·07	0·08	0·08	0·08	0·08	0·100	0·100	0·080	0·07	0·08
Containing :—										
Calcium carbonate ...	0·025	0·010	0·040	0·030	0·050	0·040	0·030	0·020	0·020	0·030
Calcium sulphate ...	0 007	...	...	...	...	...	0·013	...	...	...
Magnesium carbonate ..		0·015	...	...	...	...	...	0·013	...	0·018
Magnesium sulphate ...	0·009	...	0·010	0·020	0·010	0·025	0·009	0·013	0·020	0·010
Magnesium chloride ...	0·026	...	0·009	0·009	0·018	0·013	0·009	...	0·010	...
Sodium bicarbonate ...	...	...	...	...	...	...	...	...	...	...
Sodium sulphate ...	...	0·030	...	...	...	...	...	...	...	...
Sodium chloride ...	...	0·011	...	...	...	0·005	...	0·023	0·011	0·023
Magnesia in other forms ...	...	...	0·009	0·005	0·007	...	0·010	...	...	...

N.B.—These Nos. correspond to those given in Appendix III.

APPENDIX VI.

Copy of D. O. No. 643 of 17th October, 1918.

From the Agricultural Chemist to the Government of Bombay, Poona, to the Superintendent, Agricultural Station, Gokak.

I have been able at last to send you the figures of analysis of the samples of *gur*, soils and waters which you sent to this office with your letter No. 871 of June 14, 1918.

I hope the figures will be of use to you in drawing some definite conclusions as to the causes which affect the keeping quality of *gur*. They must, however, be taken with due regard to such other factors as the condition of the crop at the time of harvest, Brix reading of the juice, effect of manures used and such others as indicated in your D. O. 812, dated June 12, 1918.

If we compare the figures of glucose and sucrose in all the five samples, we find that Nos. 4 and 5 contain the largest amount of sucrose and the least amount of glucose and these two are solid and hard samples. Next to these in percentage of sucrose stands sample No. 2, but the percentage of glucose in it is very high and the sample is soft and sticky. Sample No. 1 contains less sucrose than No. 2 but at the same time the percentage of glucose is less and the sample is solid. Sample No. 3 contains nearly the same percentage of glucose as No. 1 but the percentage of sucrose is very low and the *gur* is a semi-solid sticky mass.

If we compare the soluble constituents in the ashes of the different *gurs* we find that Nos. 2 and 3 which are sticky contain the highest amount of alkalinity calculated as sodium carbonate. These two samples also contain the highest amount of chlorine.

If we now compare the analysis of water, we find that sample No. 1 is decidedly better than either No. 2 or 3 both of which contain too much of magnesium salts and particularly chlorides. These two waters have been used in the case of the two sticky samples of *gur*, *viz.*, Nos. 2 and 3.

As regards soils, I do not think any comparison can be made to show differences which are likely to affect the keeping quality of the different samples of *gur*.

The comparisons made above apply only to the 5 samples of *gur* sent but whether they are applicable in the majority of cases is doubtful.

STUDIES IN THE CHEMISTRY OF SUGARCANE.

BY

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I. INTRODUCTORY.

THIS investigation was taken up, in the year 1914, at Dr. W. H. Harrison's suggestion.

At the Government Cane-breeding Station, Coimbatore, thousands of sugarcane seedlings have to be tested every year within a comparatively short harvesting season, this requiring the concentrated attention of a number of men. If means could be devised to test the seedlings at a comparatively early age, say, when they are about eight months old, the work of chemical examination and selection could be spread over a greater portion of the year, thus avoiding abnormally high pressure of work at the ripening season. With this object in view, a series of preliminary experiments were instituted. The results of these investigations have not yet reached the stage of completion, but the subsidiary results so far obtained are of an interesting nature, and it was, therefore, thought desirable to publish them.

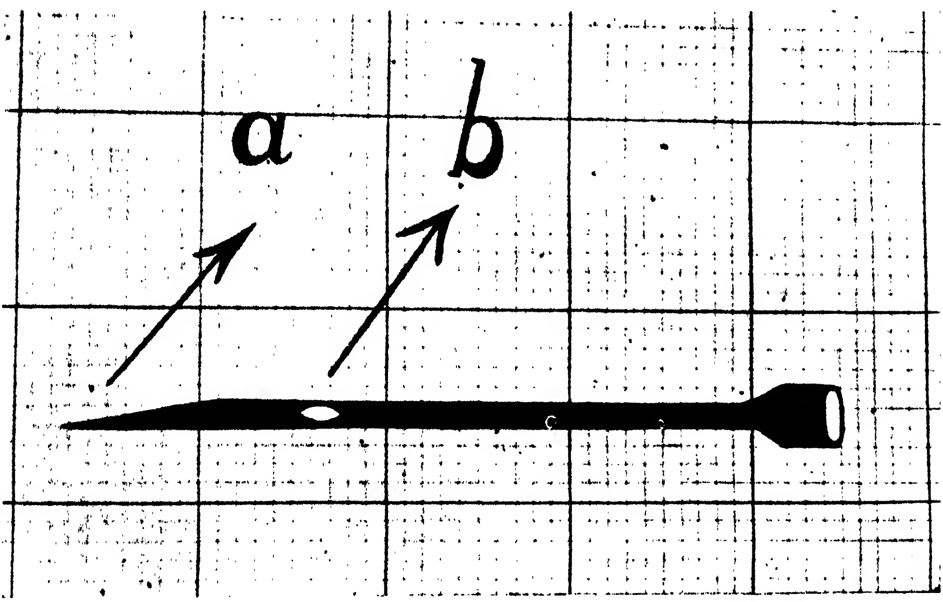
The value of a sugarcane seedling depends, from a commercial point of view, mostly on its sugar content; and to determine this, it is essential that its juice should be examined. The usual methods of analysis do not, when a cane is young, tell us what it would be after maturity. Moreover, these methods involve the destruction of the cane before the juice can be examined. It is well known that canes of the same age and belonging to the same clump vary within very wide limits. Such being the case, the results of analysis

of a young cane cannot be compared with those of an old cane of the same clump. To know what a young cane will be at the time of harvest, requires a preliminary knowledge of the life-history of the cane as told by itself. It thus becomes necessary to test a cane periodically during the various stages of its growth, and this resolves itself into devising a method for extracting a small quantity of juice from the cane sufficient for purposes of examination without appreciably interfering with its growth.

II. Preliminary.

Method of extracting juice.

A number of methods for extracting the juice from the sugar-cane were tried, and in the end the following method was found to be most suitable. The sharp open end of an ordinary hypodermic needle (*a* in Fig. below) was plugged with melted tin and a small hole was bored in the side of the needle at *b* as in the figure.



The needle when inserted in a slightly slanting position—this can be easily carried out with a little practice—into the internode

of a sugarcane, ruptures the neighbouring cells during its passage, and the juice from these cells passes into the needle by the side hole. By this means about two drops of juice can be obtained.

Injury to the cane likely to occur on account of puncturing.

The needle while passing through the cane, besides rupturing the neighbouring cells, also introduces fermentative organisms. To ascertain the extent of damage likely to occur on this account, a number of canes were punctured with a sterile needle at three or four places in each internode, and the holes thus made were immediately closed with soft paraffin. Another set of canes were punctured in the same way; only the needle was not sterilized and the holes were not closed with paraffin. At the end of one month all the canes were cut longitudinally and the state of affairs noted. It was found that the canes covered with paraffin were practically unaffected except for a thin reddish streak in the region of the path of the needle, while, in the case of those not covered with paraffin, the streaks were broad, and in a few cases signs of fermentation were also noticed. The canes were found to be otherwise normal in every case. It is thus clear that this method of extraction, with necessary precautions, by the modified form of hypodermic needle, gives juice without affecting the cane to any appreciable extent. Additional proof of this will be found later in the course of this paper.

Method of examining the juice.

The quantity of juice obtained as above permits of only one method of examination, and that is the determination of the index of refraction of the sample of juice and the deduction therefrom of the percentage of total solids calculated as sucrose. An extraction gives sufficient juice to give a clear field with the Abbe refractometer, the instrument used throughout this work.

According to W. E. Cross,[1] who gives a resumé of the various opinions on the use of the refractometer, the work of Hugh Main,

[1] Cross, W. E. *Louisiana Tech. Bulletin No. 135.*

Tollman, and Smith and Stolle showed conclusively the absolute reliability of the refractometer for determining the percentage of sugar in solution. Much work has been done on the various aspects of the use of refractometer, among which may be cited Wiechmann's refractometric studies,[1] Pellet's investigations,[2] and the experiments of Nowakowski and Muzyuski[3] who recommended the use of the Abbe instrument for juices, syrups, and molasses, as giving results which are better than those of the picnometric method, and which indeed approximate very closely to those of the drying method.

The scale of the Abbe instrument is graduated to three places of decimals, the fourth place being estimated by the eye. A maximum error of 0·0001 in the refractive index corresponding to $\pm 0{\cdot}1$ per cent. of the dry substance may be obtained.

The method of extraction and examination of the juice was as follows :—

The cane was punctured with the needle sterilized in an ordinary spirit lamp flame and cooled, and the small quantity of the juice that passed into the needle was dropped on the lower half of the prism of the refractometer. The two halves of the prism were immediately closed and the scale reading and the temperature of observation recorded. The needle was then thoroughly washed, both inside and outside, with distilled water and dried ready for the next puncture. The puncture made in the cane was immediately closed with a small quantity of soft paraffin. The corrected percentages of total solids on the basis of sucrose were next calculated from the observed scale readings. It was found that, with a little care and experience, successive extractions of juice from a single internode of a cane gave juice of practically the same refractive index. That the concentration of the juice in any part of the internode is the same, will be seen in a subsequent page.

[1] Cross, W. E. *Louisiana Tech. Bulletin No. 135.*
[2] *Ibid.*
[3] *Ibid.*

The refractive indices of sugars and other salts found in sugar-cane juices.

The juice of the sugarcane consists mostly of a mixture of sucrose, glucose and a small quantity of salts and other substances. It is important, therefore, to ascertain beforehand how these substances interfere with the refractometric readings. To obtain information on these points, the refractive indices of solutions of pure sucrose and glucose at different concentrations were determined. Pure sucrose (99·9 per cent.) and pure dextrose (99·6 per cent.) were taken, and solutions of these, varying from 1–10 per cent., were examined in the refractometer.

TABLE I.

Showing the refractive indices of sucrose and glucose solutions at various concentrations.

Strength of solution %	Temperature of observation °C.	Sucrose n_D	Sucrose Solids at at 28°C. %	Dextrose n_D	Dextrose Solids at at 28°C. %
1	28	1·3337	1·10	1·3335	1·00
2	28	1·3350	2·05	1·3350	2·05
3	28	1·3365	3·05	1·3365	3·05
4	28	1·3380	4·05	1·3381	4·10
5	28	1·3396	5·10	1·3395	5·05
6	28	1·3410	6·05	1·3408	5·90
7	28	1·3425	7·05	1·3424	7·00
8	28	1·3440	8·05	1·3440	8·05
9	28	1·3455	9·05	1·3456	9·10
10	28	1·3471	10·10	1·3470	10·05

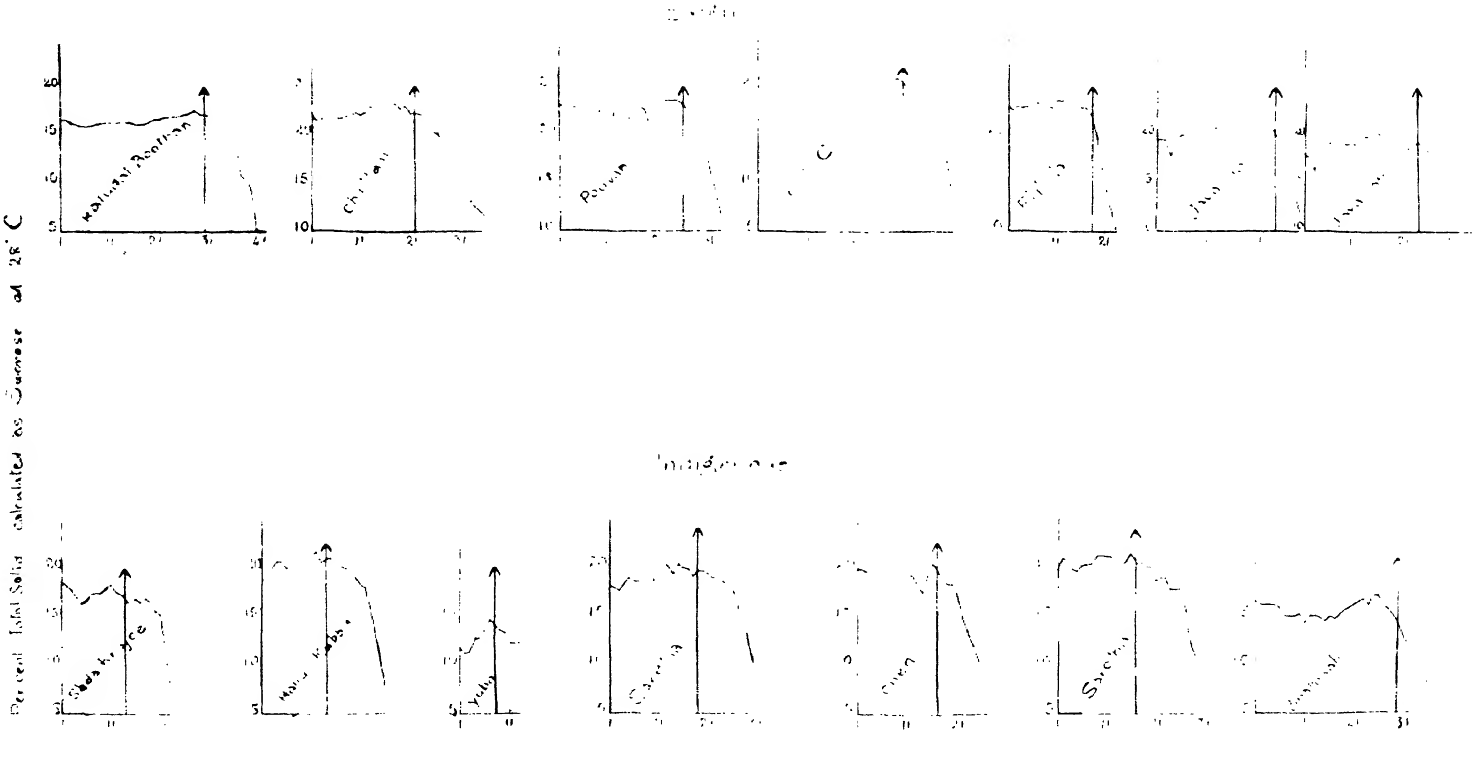
These results are in accordance with those of Stolle[1] and Tollman and Smith[2] who showed that, at all concentrations, glucose and sucrose in solution have the same refractive index. The latter authors have further shown that sucrose, fructose and glucose all have the same indices of refraction in solutions of concentrations

[1] Stolle. *Zeit. Ver. Zuckerind,* 1901; from *Louisiana Bull. No. 135.*

[2] *Journ. Amer. Chem. Soc.*, Oct., 1906.

CHART I.

Sugar Content of each Internode of maturing Sugarcanes.



Internodes from bottom to top of cane up to the very tender portion

N.B. Arrows indicate position of highest dead-leaf

Sugar Conten ernodes a various Stages Growt

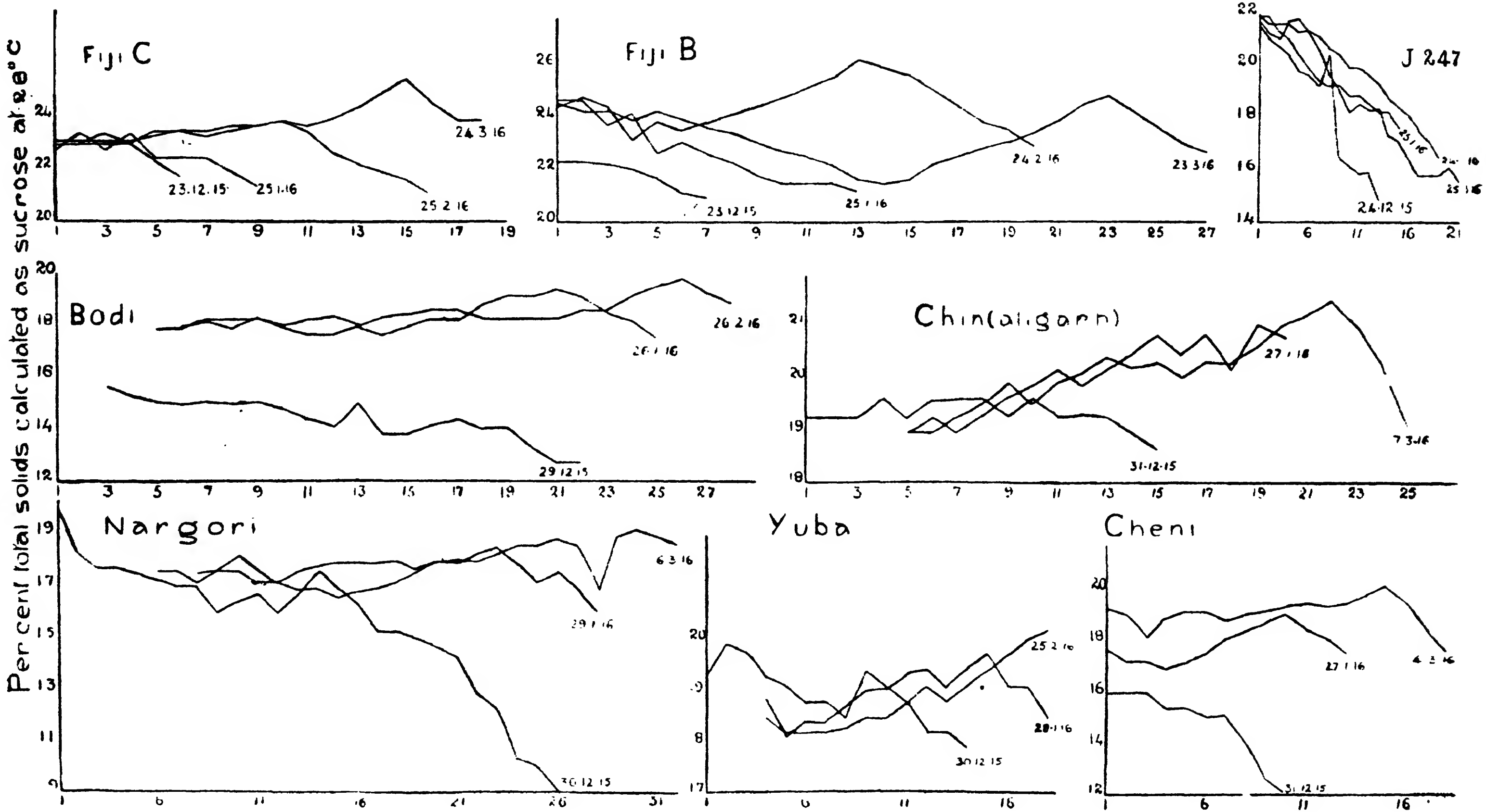
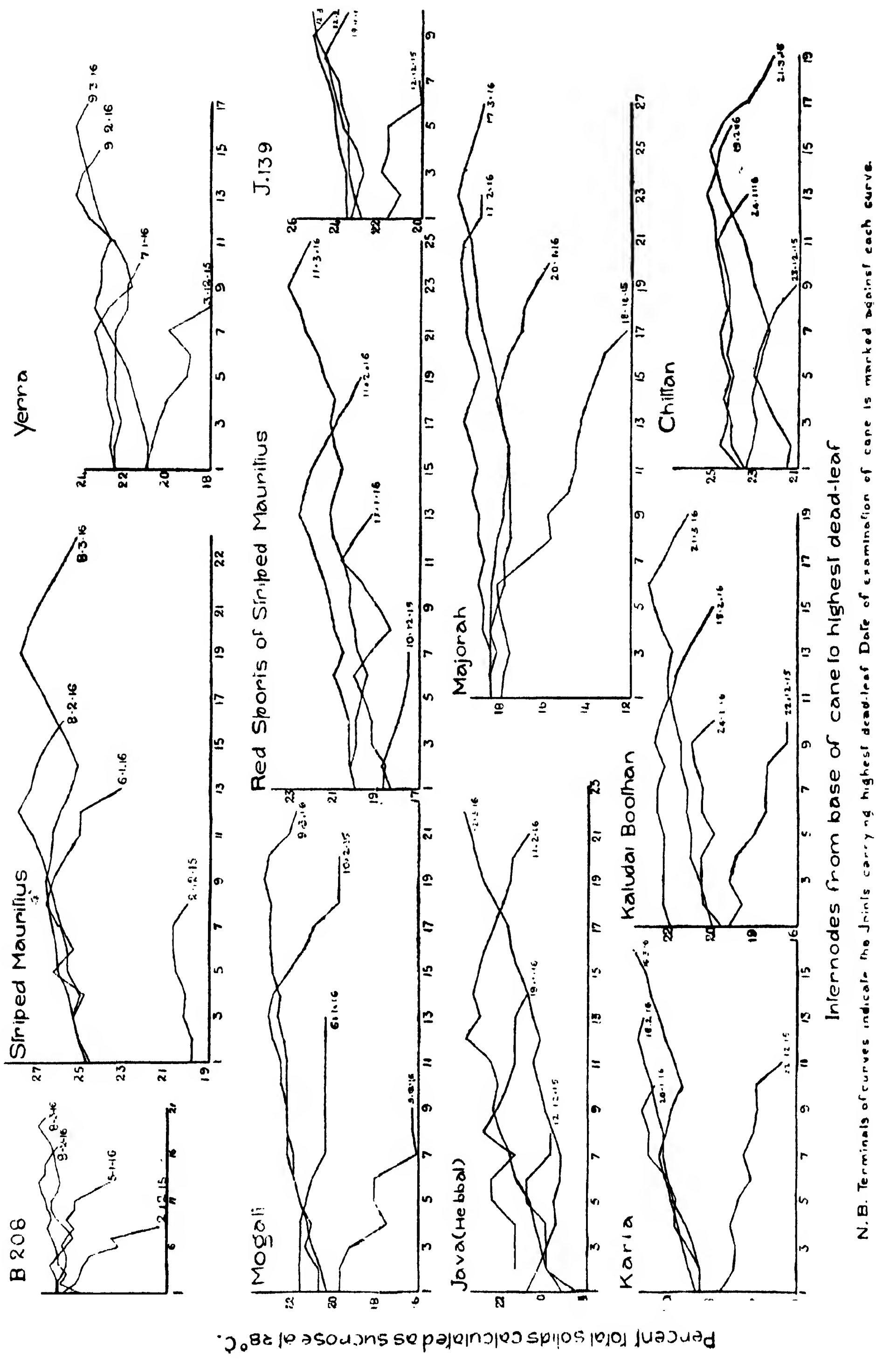


CHART II.



B 208
Striped Mauritius
Yerra
Mogoli
Red Sports of Striped Mauritius
J. 139
Java (Hebbal)
Majorah
Karia
Kaludai Boothan
Chittan
Internodes from base of cane to highest dead-leaf
Percent total solids calculated as sucrose at 28°C.
N.B. Terminals of curves indicate the Joints carrying highest dead-leaf. Date of examination of cane is marked against each curve.

0–90 per cent. Subsequently Prinsen Geerligs[1], working with the Abbe instrument, first confirmed the observations of Tollman and Smith[2] regarding the specific refraction of sugars, and then obtained data on such salts as chlorides, sulphates, acetates, etc., as are commonly found in the sugarcane products. He showed that calcium salts had a higher, and the potassium salts a lower, index of refraction than sucrose, and proved by experiment that a mixture of these salts, such as is usually found in sugar products, gave results very nearly the same as those of pure sucrose. The amount of salts to be met with in cane juices is very small, and any slight fluctuation in the total solids calculated as sugar is, therefore, negligible.

III. Experimental.

Having worked through the initial difficulties, the next step in the course of the investigation was how best to apply the above methods to a growing sugarcane to determine its sucrose-yielding efficiency. The object aimed at was to fix the status of a seedling by examining the juice of a single internode in that particular cane. The main difficulty was how to locate the internode which would serve as an index for the whole cane within the limits of experimental error.

Venkataraman and Krishnamurti Row[3] made sectional analyses of sugarcanes and have shown that the highest sucrose content (which they call sucrose index of the cane) is found in the young cane in the lowest section, but as the cane advances in maturity, the region of the highest sucrose content gradually moves upwards. They based their conclusions on analyses made of different canes belonging to the same clump, after dividing these into 5 or 6 parts from the bottom. Their results, therefore, refer to portions of cane but not to particular internodes, and consequently cannot be of help in determining the particular internode or internodes which would serve as an index to a cane. Besides, their results refer to sucrose as determined by the polariscope, while the results in this paper

[1] Cross, W. E. *Louisiana Techn. Bull. No.* 35.

[2] Loc. cit.

[3] *Agric. Journ. India,* Spl. Indian Science Congress Number, 1917.

refer to the total sugars. A number of sugarcanes, kindly supplied by the Government Cane-breeding Station, were examined joint by joint from bottom to top, noting the places of highest dead leaf, lowest living leaf, and other botanical peculiarities, with a view to ascertaining how the total sugars are distributed in the cane. The results of 14 canes thus examined are tabulated in Table II (p. 458) and plotted in Chart I. The canes examined consisted of both exotic and indigenous varieties.

One striking point of difference between the indigenous and exotic canes is that the fall in the percentage of total solids is very steep or sudden in the case of the exotic canes, while it is more gradual in the case of the indigenous ones, thus showing a marked difference between the two varieties.

It will be seen that in many cases the joint at or very near the highest dead leaf contained the maximum amount of sugars, while in the case of some it was removed as far below as 5 or 6 joints towards the base. In no case was it above the highest dead leaf joint from the bottom. The botanical notes show that the canes were almost ripe at the time of sampling.

W. C. Stubbs[1] says, "each joint has its leaf and through the latter the food of the former is assimilated, and it is believed when the joint casts its leaf, the process of assimilation ; so far as that joint is concerned, is completed—it is mature." If this be the case, one would expect a flat curve, *i.e.*, uniform sugar content from the bottom of the cane up to the highest dead leaf joint, or if any deterioration is taking place in the lower joints an inclined curve with its maximum about the highest dead leaf joint and exhibiting a gradual fall above the dead leaf joint. The curves in Chart I do not seem to endorse this view. The maximum sugar content is not at the highest dead leaf joint in all cases, nor is it located at any definite distance from the highest dead leaf joint except that it is never above this point.

It is possible that the canes examined were of different degrees of ripeness and consequently the internode containing the maximum

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[1] Stubbs. *Sugarcane*, vol. I, page 14.

sugar content is removed more or less from the highest dead leaf. In order to test this point a number of seedling canes of about nine months old, both exotic and indigenous, were examined, from the internode just above the ground level to that carrying the highest dead leaf, at intervals of one month. The results obtained are tabulated in Table III (p. 467) and graphically described in Chart II.

It will be seen that when the cane is young the point of maximum sugar content is in the basal sections, but as the cane matures, this gradually moves up the cane towards the highest dead leaf joint. These results are in complete accord with those of Venkataraman and Krishnamurti Row[1] whose work started simultaneously with the author's but was quite independent and was carried out by methods of experiment entirely different from those employed by the author. The results suggest that in a young cane the sugar content of the internode nearer to the ground gives roughly an idea of the capacity of the seedling.

With this information, a number of B. 208 seedlings were examined in 1916 when they were about nine months old, and the results were compared with those obtained by crushing the same canes after maturity, as well as with the bulk harvest results of the same clump. A similar set of experiments were made in the year 1917. In both cases the results obtained are not entirely satisfactory; nevertheless, they are encouraging in that nearly 70 per cent. of the results corresponded with the preliminary tests though the rest failed to keep up to the original indications. The cause of this difference is being investigated, and this portion of the work will be carried on as opportunity occurs.

Subsidiary results.

An examination of the curves in Chart II shows that :—

1. When the cane is *young*, the joint with the highest dead leaf contains the lowest amount of sugar of all the dead leaf joints, but its sugar content gradually increases, however, as the cane

[1] Loc. cit.

matures, thus indicating that further storage of sugar takes place after the leaf is dead.

2. As the cane grows there is a general levelling about the middle of the curves indicating either the possibility of the sugar moving upwards from internode to internode or its being used up in the lower joints in the building up of cane tissue.

3. A large increase in the amount of total sugars occurs in the internode even after the leaf is dead and cast.

There are thus strong indications in favour of formation of sugars in the internode after its leaf is cast, and it was thought desirable to obtain further proof in support of this view. Barnes[1] has shown that when cut, after-ripeness actually occurs in sugarcane under proper conditions. His results, though not conclusive, were based on experiments made with different canes, and this fact minimises the importance of the conclusions drawn. An attempt was, therefore, made to experiment with one and the same internode of a sugarcane by cutting this into two halves and watching if any increase in sugars occurred in one of the halves when kept for some time. As a preliminary to this, experiments were made to ascertain if the concentration of the juice is the same throughout an internode.

Two samples were taken from an internode by means of a cork-borer and the sugars from these were extracted by means of 80 per cent. alcohol and examined.

TABLE IV.

Showing the sugar content of two portions of an internode.

No. of experiment	Bottom		Top	
	Sucrose	Glucose	Sucrose	Glucose
1 ..	1·34	Trace	1·34	Trace
2 ..	1·38	"	1·38	"
3	1·26	"	1·25	"
4 ..	1·89	"	1·88	"

[1] Barnes, J. H. *Agric, Journ. India,* April, 1917.

Having ascertained that the concentration of the juice of an internode is uniform, the following series of experiments were made.

The canes after being brought to the laboratory were stripped of their leaves, and two internode lengths about the dead leaf joint were cut off with a sterile knife. The cut portions were next cut into two halves longitudinally, so that each half had one bud and root zone intact. One of the two longitudinal halves was incubated in a cool place for about 48 hours. The other half was quickly dropped into boiling alcohol (containing 1 part ammonia in 100 parts of alcohol) so as to bring to a sudden stop all vital activity in the cane. This was next removed from the alcohol, dried and reduced to a powder. The sugars were afterwards extracted with alcohol (80 per cent.), the solvent distilled off, and the residual sugars examined according to the methods of Davis[1], and of Davis, Daish and John.[2] At the end of 48 hours the other halves were also submitted to the same treatment and analysed (Table V).

TABLE V.

Showing the effect of storage on portions of internodes of sugar-canes preserved for 48 hours in a cool place.

Name of cane	Total solids on dry matter %			Sucrose on dry matter %			Glucose on dry matter %		
	Initial	Final	+ or −	Initial	Final	+ or −	Initial	Final	+ or −
Green Sports of Striped Mauritius ..	66·50	61·40	− 5·10	49·57	43·30	− 6·27	11·43	10·90	− 0·53
Ditto ..	64·15	69·71	+ 5·56	49·69	57·82	+ 8·13	2·56	2·55	− 0·01
Striped Mauritius	58·70	62·80	+ 4·10	40·60	45·71	+ 5·11	8·29	9·17	+ 0·88
Ditto ..	49·80	54·90	+ 5·10	38·70	46·00	+ 7·30	11·25	10·50	− 0·75
Ditto ..	60·20	63·10	+ 2·90	48·10	50·00	+ 1·90	7·26	7·30	+ 0·04
Ditto ..	38·10	46·40	+ 8·30	28·70	33·40	+ 4·70	12·16	12·00	− 0·16
Ditto ..	52·40	53·80	+ 1·40	45·80	46·50	+ 0·70	6·29	8·00	+ 1·71
Ditto ..	60·30	65·80	+ 5·50	48·60	54·40	+ 5·80	4·51	4·40	− 0·11
Kaludai Boothan	57·80	65·40	+ 7·60	48·40	56·30	+ 7·90	Traces	Traces	
Ditto ..	62·40	52·80	− 9·60	51·50	41·70	− 9·80	Do.	Do.	
Ditto ..	50·30	50·03	− 0·27	36·10	35·13	− 0·97	3·31	4·75	+ 1·44
Ditto ..	56·90	54·30	− 2·60	30·62	35·90	+ 5·30	6·00	11·00	+ 5·00

[1] Davis. *Journ. Agric. Science,* 1916.
[2] Davis, Daish and John. *Journ. Agric. Science,* 1913, 1914 and 1915.

Out of the twelve experiments made, there was a distinct increase of sugars and total solids in eight, while the other four experiments showed loss of sugars and total solids. These results are not, of course, conclusive, but they certainly indicate extra formation of sugars. It is possible that the loss of sugar and total solids on four occasions may have been due to bacterial fermentation, though every effort was made to ensure sterility. Since submitting this paper to the Chairman of the Agricultural Section of the Indian Science Congress, the Annual Report of the Agricultural Research Institute, Pusa, was published, wherein Dr. Harrison records an increase of both total solids and sugar in two varieties of canes under windrowed conditions.

Discussion of the results.

Before proceeding to discuss the results it is well to see how far the methods of experiment employed affected the canes examined. The shape of the curves cannot be attributed to any changes resulting from puncturing the canes, because if that were the case the lower portions of the curves could not have been steady as they are seen to be in almost all the cases.

The probable error due to the refractometer has been dealt with when dealing with that instrument. The error due to the methods of extracting the juice from the cane cannot be exactly estimated, but the extractions were all made under conditions as uniform as possible, and any error is believed to be constant or nearly so. As for temperature the necessary corrections were applied to all the readings. The total solids calculated from the refractive indices were all taken to represent sugar, as the amount of substances other than sucrose and reducing sugars is so small that they may be neglected. Besides, it has already been shown that sucrose, glucose and other salts usually found in sugarcane juice have the same refractive index.

It is not claimed that the results so far obtained are in any way complete, but there can be no doubt as to the general indications, particularly in view of the fact that they are in general agreement

with those of Venkataraman and Krishnamurti Row[1] who drew their conclusions from entirely different methods.

A consideration of the foregoing results brings us at once to the question, " how does the cane make its sugar." A large volume of literature exists on the formation of sugar in the beet, but the amount of work done on the formation of sugar in the sugarcane, judging from the literature at the author's disposal, is meagre and controversial.

Ainne Girard[2] in 1884, from comparative investigations of the amounts of cane sugar and grape sugar present in different parts of the sugarcane in the afternoon and before sunrise, concluded that the formation of sucrose from glucose takes place entirely in the leaves under the influence of sunlight and that the sucrose thereupon ascends the cane through the petioles, etc., and collects there.

Winter[3] (1888) from an examination of the sugars of a normal ripe sugarcane says that the assumption that sucrose is formed from glucose and levulose can no longer be allowed.

Beeson[4] (1895) regards glucose as the first assimilation product.

Prinsen Geerligs[5] (1896) concludes from data furnished by estimations of the optical and reducing powers before and after inversion, that the ratio between sucrose, dextrose and levulose in the leaves from the unripe sugarcane is 1 : 2 : 4. In the upper portion of unripe canes of six months' growth the ratio was 1 : 1 : 1, three months later it became 3 : 2 : 1, whilst in the lower joints of canes nine months old the ratio found was 82·5 : 3 : 1. He thus maintains that sucrose is built up from reducing sugars.

Went[6] (1898) made a thorough study of this question and concluded from a microchemical examination of the sugarcane that

[1] Loc. cit.

[2] Ainne Girard. *Compt. Rend.*, XCVII, 1305; abstract *Journ. Soc. Chem. Industry*, 1884.

[3] Winter. *Zeit. f. Zuckerind*, 1880, 780; abstract *J. S. C. I.*. 1888, p. 761.

[4] Beeson. *Bull. Assoc. Chem.*, 1895, XIII, 362; abstract *J. S. C. I.*, 1895.

[5] Prinsen Geerligs. *Chem. Zeit.*, 1896, XX, 721; abstract *J. S. C. I.*, 1896.

[6] Went, P A. F. C. *Bull. de l'Assoc. des Chemi. de Sucr. et de Dist.*, 1898, 15(12), pp. 1217–1226; abstract *J. S. C. I.* and *Cane Sugar* by Noel Deerr.

glucose, sucrose, starch and tannin are found in the parenchymatous cells and not in the vascular bundles while the contrary is the case with the albuminoids. According to this investigator the following phases are distinguished in the life-history of the stalk:

(1) In very young parts of the stalk, only starch and albumen are present, which are consumed little by little in the formation of cellulose.

(2) In young, rapidly growing parts of the stalk, the cane sugar brought down by the leaf is inverted, and whereas in the leaf the proportions of sucrose, dextrose and levulose were as 4 : 2 : 1, in the young joints the proportions are 0·8 : 1 : 1. A part of the invert sugar is used up in the formation of fibre, a part unites with the amides to form albumen, and a part is deposited as starch. In consequence of the inversion, the osmotic pressure is raised and this tends to favour the absorption of plant food.

(3) In older joints the sucrose formed in the leaf remains unchanged when it reaches the joint and the reducing sugars are used up, partly in respiration, or perhaps partly converted by a synthetic enzyme action into sucrose; of the reducing sugars that remain, the dextrose is generally in excess.

(4) When the stalks are developed, the accumulated invert sugar is converted into sucrose; of the invert sugar remaining, the dextrose is generally in excess.

(5) When the stalks are ripe the leaves die and the accumulation of sugar gradually ceases; the remainder of the invert sugar is changed to sucrose, eventually only traces of invert sugar remaining.

(6) When the stalks are overripe the sucrose is reconverted into invert sugar, but this change does not prevent the younger parts of the cane accumulating sugar. It will be noticed that Went's figures for the ratio between sucrose and reducing sugars in the leaf are entirely different from those formed by Geerligs.

Pellet [1] (1914) maintains that the results obtained by him point to conversion of the reducing sugars into sucrose after reaching the cane stalk. Colin[2] (1914) takes a similar view.

Other investigators on beet-root and foliage leaves are divided, as in the case of the sugarcane investigators, some holding sucrose and some glucose as the product directly formed in and translocated by the leaf.

The most recent investigators in this field are Davis and Colin. Davis[3] (1915-1916) after a very careful examination of the carbohydrates of the leaves of the mangold concludes that the sugar is translocated by the leaf as hexoses which are subsequently transformed into sucrose.

Colin[4] (1916-1917) has stated that sucrose contained in the beet-root is reproduced by a small number of cells from the reducing sugars and that normally invertase is not present in the root. The same investigator in a later communication[5] criticises the two theories advanced, in the light of the latest researches, and concludes that sufficient evidence has not yet been obtained to establish the proposition that sucrose cannot pass unchanged from the leaf to the root. Moreover, he admits that there exists considerable evidence pointing to the polymerisation of reducing sugars into sucrose in the beet-root.

The bulk of evidence seems to favour the view that sucrose in the sucrose-storing plants is built up either in the root or in the stem from the reducing sugars sent into it by the leaf. Analyses of top and bottom halves of sugarcane made in this laboratory (Table VI) show that the top halves contain more glucose than the bottom halves and this is apparently in general accord with the views just quoted above.

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[1] **Pellet.** Private communication to Mr. W. A. Davis quoted in *Journ. Agric. Science*, vol. VII, 1915-1916.

[2] *Journ. Agric. Science*, vol. VII, 1915-1916.

[3] **Davis.** Loc. cit.

[4] **Colin.** *Rev. Gen. Botan.*, XXVIII, 289–99, 321–8, 368–80 (1916), XXIX, 21–32, 56–64, 89–96, 113–27 (1917), from *Chem. Abstracts*, vol. XII, 1918.

[5] *Bull. Chem. Suer. Dist.*, 35 (171–178), 1917, from *Chemical Abstracts*, vol. XIII (1918).

TABLE VI.

Showing analyses of top and bottom halves of sugarcane.

Name of cane	Bottom half			Top half		
	Sucrose	Glucose	Ratio glucose/sucrose	Sucrose	Glucose	Ratio glucose/sucrose
	%	%		%	%	
B. 147	14·11	1·31	0·09	13·35	1·61	0·11
Fiji B.	18·02	0·70	0·04	14·66	1·43	0·09
B. 1529	18·68	0·27	0·01	17·92	0·40	0·02
B. 3412	14·82	1·25	0·08	12·91	1·35	0·10
J. 247	14·04	1·04	0·07	13·18	1·39	0·11
B. 6450	16·37	0·40	0·02	15·09	1·04	0·07
Tana Blanche ..	15·55	0·78	0·05	13·56	0·88	0·06
Ashy Mauritius ..	19·04	0·21	0·01	17·44	0·39	0·02
Red Mauritius sports ..	14·69	1·67	0·11	14·05	1·78	0·12
B. 208	18·95	0·42	0·02	18·19	0·60	0·03
Fiji C.	15·69	0·63	0·04	13·95	0·83	0·06

From a study of the previous literature we learn that all are agreed that *sugar* in one form or other is sent to the cane by the leaf, and nothing is said of the fate of the sugar when once it enters the stalk. It is only an assumption, without direct experimental evidence, that sucrose is the result of polymerisation of the reducing sugars. It has been shown that sucrose and reducing sugars have the same refractive index, and if nothing more than conversion of reducing sugars into sucrose takes place after the leaf is cast, there is no need for any increase in the total solids as shown by the refractometer. The results of experiments detailed in this paper distinctly show that there is an increase in total solids with production of sugar in large quantities in an internode after the death of the leaf attached to it. How is this extra sugar formed ?

The explanation that readily suggests itself from a study of the curves in Chart II is that, as the cane grows, the internodes are gradually filled up by the sugar sent in by the living leaves above. If this is so, the amount of work falling on the green leaves produced during the later stages of the growth of the cane, is greater than that carried out by the earlier leaves, and this appears to be too much for the new ones. It cannot be argued that increased output

is possible on account of increase in leaf area. In sugarcane each internode has only one leaf and old leaves die off as new ones come up. In India it takes about twelve months from the time of planting for a cane crop to mature, and as the canes were examined when they were about eight months old and thus at a sufficiently adult stage at the time of examination, there could not have been any considerable difference between the total leaf area at the beginning and closing stages of the experiment.

The green leaves have their own urgent work to do. They have to provide large quantities of sugar for the building up of their internodes and proteids, besides sending down material to older joints for purposes of storage. This would appear to be an undue strain on the existing green leaves, and it does not seem reasonable to suppose that when the demands from the growing parts are urgent the leaves would make an attempt at supplying the lower joints which could not be provided for by their own leaves with sugar.

Another possible explanation is that the sugars as soon as they are sent in by the leaf into the stem are converted into carbohydrates of higher molecular weight of the types of hemicelluloses, starch and such others for purposes of building up cane tissue. These after the death of the leaf are slowly reconverted into simple sugars. The formation of cellulose-like substance from sucrose in beet juice by a ferment resembling diastase was observed by E. Durin.[1] Brown and Morris[2] as a result of their investigations on tropeolum leaves hold the view that cane sugar is the precursor of cellulose. This view is also supported by Cross and Bevan.[3] Dr. Maxwell[4] in 1893-1894 found in the sugarcane bodies resembling gums which on hydrolysis yielded glucose. He was then not able to explain the physiological significance of the presence of these bodies in sugarcane.

Small quantities of starch as a sheath round the vascular bundles and diastase were recognized by the author in the younger joints of

[1] Durin. *Compt. Rend.*, LXXXII, 1078; LXXXIII, 128.
[2] Brown and Morris. *J. C. S.*, 1890, LVII. 458.
[3] Cross and Bevan. *Cellulose.*
[4] Maxwell. *Louisiana Bull.* No. 38.

the cane while none could be found in the older joints. It is possible that the diastase is functioning both as disintegrator and builder of complex carbohydrates. It is also possible in view of the evidence adduced that the function of the leaf is a physiological one, growth continues as long as the leaf is alive, and during this time the tendency of the internode is to build up higher polysaccharides for its own benefit from the sugar sent in by the leaf till the connection with the leaf is cut off, and that after the death of the leaf re-elaboration of the material takes place as observed by Stubbs.[1]

Thus, with our present knowledge of the physiology of sugar-cane, two methods of explanation seem possible. Which of the two is more tenable has to be shown by further investigation. The bulk of the evidence adduced seems to favour the second view.

IV. Summary and conclusions.

The results so far obtained may be summarized thus :

(1) A method of extracting and examining small quantities of juice from sugarcane, without harming the cane to any appreciable extent, was devised.

(2) By the application of the above method the total sugar content of each joint of sugarcane was determined during the various stages of its growth, thus obtaining a glimpse into the life-history of the cane, as told by itself.

(3) In a young cane the maximum amount of total sugars is found at the basal joints ; as the cane grows older and older, this maximum sugar content moves higher and higher till it is at the highest dead leaf joint. The nearer the maximum total sugar content is to the highest dead leaf joint, the more advanced it is in maturity.

(4) A large increase of sugars occurs in the internode of the cane after the death of its attendant leaf ; this increase

[1] Loc. cit.

may be due either to the influx of sugars from the growing parts above or to further elaboration of the material already sent in by the leaf before its death. What it exactly is, is to be decided by further investigation.

(5) The formation of sucrose in the cane does not seem to be due to such a simple process as the direct polymerisation in the stem of reducing sugars translocated by the leaf, as is generally supposed to be the case.

In conclusion, I have to express my deep sense of gratitude to Dr. C. A. Barber, C.I.E., Government Sugarcane Expert, for freely affording facilities for work at the Government Cane-breeding Station, Coimbatore, to Dr. W. H. Harrison for suggesting this investigation, and to Dr. R. V. Norris for criticism of the results and advice before the paper was finally written up.

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TABLE II.

Showing the total sugar content of each internode of maturing sugarcanes as shown by the refractometer.

No. of internode from base	Observed n_D	Observed temp. °C	Total solids calculated as sugar at 28°C. %	REMARKS
		KALUDAI BOOTHAN.		
1	1·3595	27·0	17·98	Cane maturing.
2	1·3595	27·2	17·99	
3	1·3590	27·5	17·71	
4	1·3580	27·5	17·06	
5	1·3575	27·3	16·74	
6	1·3575	27·3	16·74	
7	1·3576	27·3	16·79	
8	1·3578	27·4	16·96	
9	1·3583	27·0	17·23	
10	1·3584	27·0	17·33	
11	1·3585	27·1	17·38	
12	1·3587	27·2	17·54	
13	1·3585	27·5	17·41	
14	1·3586	27·5	17·46	
15	1·3586	27·6	17·45	
16	1·3578	27·6	16·95	
17	1·3578	27·6	16·95	
18	1·3580	27·6	17·05	
19	1·3590	27·6	17·70	
20	1·3595	27·6	18·00	
21	1·3595	27·5	18·01	
22	1·3600	27·4	18·31	
23	1·3600	27·4	18·31	
24	1·3605	27·4	18·61	
25	1·3605	27·4	18·61	
26	1·3610	27·4	18·91	
27	1·3615	27·5	19·21	
28	1·3626	28·0	19·90	
29	1·3612	28·0	19·05	
30	1·3610	28·4	18·98	Base carried highest dead leaf.
31	1·3601	28·6	18·44	
32	1·3585	28·8	17·51	
33	1·3575	29·0	16·87	Half dead leaves.
34	1·3565	29·0	16·27	
35	1·3550	29·0	15·32	
36	1·3530	29·0	14·07	
37	1·3495	29·0	11·77	Base carried lowest fully green leaf.
38	1·3474	29·0	10·37	
39	1·3445	29·1	8·47	
40	1·3395	29·2	5·12	
41	1·3395	29·2	5·12	
42	1·3395	27·3	4·99	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n D	Observed temp C	Total solids calculated as sugar as 28° C. %	REMARKS
		SADA KHAJEE.		
1	1·3605	27·0	18·58	A healthy cane with a full green tuft. Tuft not closing.
2	1·3097	27·0	18·08	
3	1·3590	27·2	17·69	Buds lightly swelling.
4	1·3578	27·5	16·96	
5	1·3565	27·5	16·16	
6	1·3570	27·6	16·47	On cutting showed borer attack.
7	1·3584	27·6	17·37	
8	1·3585	27·6	17·42	
9	1·3585	27·8	17·44	
10	1·3590	28·0	17·75	
11	1·3600	28·0	18·35	
12	1·3585	28·0	17·45	
13	1·3584	28·0	17·40	
14	1·3575	28·0	16·80	Highest dead leaf.
15	1·3567	28·0	16·30	Do. half dead leaf.
16	1·3575	28·0	16·80	
17	1·3570	28·0	16·50	
18	1·3575	28·0	16·80	
19	1·3570	28·0	16·50	
20	1·3555	28·2	15·59	Fully green leaves.
21	1·3550	28·2	15·24	
22	1·3480	28·2	10·69	
23	1·3430	28·2	7·39	
		CHITTAN.		
1	1·3665	28·0	22·20	Cane maturing.
2	1·3652	28·4	21·47	
3	1·3655	28·4	21·68	
4	1·3645	28·5	21·09	
5	1·3650	28·5	21·39	
6	1·3655	28·5	21·69	
7	1·3655	28·5	21·69	
8	1·3657	28·6	21·85	
9	1·3660	28·6	22·00	
10	1·3665	28·6	22·25	
11	1·3660	28·7	22·00	
12	1·3665	28·8	22·26	
13	1·3673	28·6	22·75	
14	1·3670	28·5	22·54	
15	1·3670	28·5	22·54	
16	1·3675	28·4	22·88	
17	1·3680	28·5	23·14	
18	1·3680	28·5	23·14	
19	1·3670	28·2	22·51	
20	1·3675	28·2	22·86	
21	1·3662	28·3	22·07	
22	1·3663	28·4	22·12	Highest dead leaf.
23	1·3660	28·3	21·97	
24	1·3655	28·3	21·67	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n_D	Observed temp. °C.	Total solids calculated as sugar at 28°C. %	REMARKS
		CHITTAN.—*Concld.*		
	·3636	28·0	20·50	
26	·3630	28·0	20·15	
27	·3630	28·0	20·15	
28	·3609	28·0	18·90	
29	·3605	28·0	18·65	
30	·3575	28·0	16·80	
31	·3549	28·0	15·20	
32	·3515	28·0	12·90	
33	·3505	28·0	12·30	
34	·3490	28·0	11·40	
		POOVAN.		
1	1·3678	28·0	23·00	Cane maturing.
2	1·3678	28·0	23·00	
3	1·3673	28·0	22·70	
4	1·3675	28·2	22·86	
5	1·3673	28·2	22·71	
6	1·3660	28·4	21·97	
7	1·3647	28·5	21·17	
8	1·3670	28·5	22·52	
9	1·3645	28·6	21·08	
10	1·3640	28·6	20·83	
11	1·3665	28·7	22·23	
12	1·3675	28·7	22·88	
13	1·3675	28·7	22·88	
14	1·3650	28·6	21·38	
15	1·3670	28·7	22·53	
16	1·3672	28·8	22·69	
17	1·3670	28·6	22·53	
18	1·3640	28·6	20·83	
19	1·3655	28·6	21·68	
20	1·3675	28·6	22·88	
21	1·3683	28·5	23·32	
22	1·3685	28·7	23·43	
23	1·3687	28·7	23·53	
24	1·3686	28·7	23·48	
25	1·3685	28·6	23·43	
26	1·3675	28·6	22·88	Highest dead leaf.
27	1·3665	28·6	22·23	
28	1·3660	28·6	21·98	
29	1·3655	28·7	21·68	
30	1·3610	28·7	18·98	
31	1·3568	28·6	16·43	
32	1·3540	28·7	14·68	
33	1·3495	28·6	11·73	Fully green leaf.
34			No juice	
35			No juice	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n_D	Observed temp. °C	Total solids calculated as sugar at 28°C. %	REMARKS
		FIJI C.		
1	1·3640	27·0	20·73	
2	1·3645	27·0	20·98	Cane nearing maturity.
3	1·3653	27·0	21·43	
4	1·3658	27·1	21·78	
5	1·3658	27·2	21·79	
6	1·3662	27·5	22·01	
7	1·3663	27·5	22·06	
8	1·3660	27·5	21·91	
9	1·3650	27·6	21·31	
10	1·3655	27·6	21·61	
11	1·3645	27·8	21·03	
12	1·3645	27·8	21·03	
13	1·3640	27·8	20·78	
14	1·3645	27·8	21·03	
15	1·3645	27·8	21·03	
16	1·3645	27·8	21·03	
17	1·3640	27·8	20·78	
18	1·3645	27·8	21·03	
19	1·3647	28·0	21·15	
20	1·3650	28·0	21·35	
21	1·3650	28·0	21·35	
22	1·3652	28·0	21·45	
23	1·3652	28·0	21·45	
24	1·3645	28·0	21·05	
25	1·3640	28·0	20·80	
26	1·3637	28·0	20·60	
27	1·3638	28·0	20·65	
28	1·3635	28·0	20·45	
29	1·3625	28·0	19·85	
30	1·3615	28·0	19·25	Highest dead leaf.
31	1·3590	28·0	17·75	
32	1·3565	28·0	16·20	
33	1·3550	28·0	15·25	
34	1·3535	28·0	14·30	
35	1·3530	28·0	14·00	Lowest fully green leaf.
36	1·3515	28·0	12·90	
37	1·3500	28·0	12·00	
38	1·3445	28·0	8·40	
		HALLU KABBU.		
1	1·3602	30·0	18·59	
2	1·3610	30·0	19·09	Cane immature
3	1·3618	30·0	19·59	
4	1·3635	30·0	20·59	
5	1·3635	30·0	20·59	
6	1·3625	30·0	19·99	
7	1·3630	30·0	20·29	
8	1·3635	30·0	20·59	
9	1·3640	30·1	20·94	
10	1·3635	30·2	20·60	
11	1·3645	30·3	21·21	
12	1·3653	30·5	21·68	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n D	Observed temp. °C.	Total solids calculated as sugar at 28°C. %	REMARKS
		HALLU KABBU.—*Concld.*		
13	1·3633	30·5	20·53	
14	1·3640	30·5	20·98	Highest dead leaf.
15	1·3640	30·5	20·98	
16	1·3630	30·5	20·33	
17	1·3628	30·5	20·23	
18	1·3625	30·5	20·03	
19	1·3620	30·5	19·78	
20	1·3605	30·5	18·83	
21	1·3597	30·5	18·33	
22	1·3590	30·5	17·92	Lowest fully green leaf.
23	1·3555	30·5	15·77	
24	1·3520	30·5	13·47	
25	1·3470	30·5	10·22	
26	1·3430	30·5	7·56	
		FIJI B.		
1	1·3675	29·5	22·95	
2	1·3670	29·5	22·60	
3	1·3675	29·8	22·97	Cane appears immature.
4	1·3673	29·8	22·82	
5	1·3673	29·8	22·82	
6	1·3682	29·8	23·32	
7	1·3680	29·8	23·22	
8	1·3683	29·8	23·42	
9	1·3682	29·8	23·32	
10	1·3670	29·8	22·62	
11	1·3675	30·0	22·99	
12	1·3675	30·0	22·99	
13	1·3675	30·0	22·99	
14	1·3677	30·0	23·09	
15	1·3677	30·0	23·09	
16	1·3670	30·0	22·64	
17	1·3660	30·0	22·69	
18	1·3655	30·0	21·79	Highest dead leaf.
19	1·3625	30·0	19·99	
20	1·3565	30·0	16·34	
21	1·3520	30·0	13·44	Lowest fully green leaf.
22	1·3495	30·0	11·84	
23	1·3460	30·0	9·54	
		J. 213.		
1	1·3615	30·0	19·39	
2	1·3615	30·0	19·39	Cane immature.
3	1·3615	30·0	19·39	
4	1·3585	30·0	17·59	Deep crack.
5	1·3615	30·0	19·39	
6	1·3625	30·0	19·99	
7	1·3625	30·0	19·99	
8	1·3624	30·0	19·94	
9	1·3635	30·2	20·60	
10	1·3639	30·2	20·85	
11	1·3640	30·4	20·97	
12	1·3635	30·3	20·61	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n D	Observed temp. °C.	Total solids calculated as sugar at 28°C. %	REMARKS
		J. 213.—Concld.		
13	1·3635	30·3	20·61	
14	1·3640	30·3	20·96	
15	1·3655	30·4	21·82	
16	1·3655	30·4	21·82	
17	1·3658	30·5	22·03	
18	1·3655	30·5	21·83	
19	1·3660	30·5	22·13	
20	1·3655	30·5	21·83	
21	1·3656	30·5	21·88	
22	1·3645	30·5	21·23	
23	1·3645	30·5	21·23	
24	1·3635	30·5	20·63	
25	1·3630	30·5	20·33	Highest dead leaf.
26	1·3615	30·5	19·43	
27	1·3600	30·5	18·53	
28	1·3575	30·5	16·98	
29	1·3530	30·6	14·19	Lowest fully living leaf
30	1·3495	30·6	11·89	
		J. 139.		
1	1·3595	26·2	17·92	
2	1·3590	26·5	17·65	Cane maturing.
3	1·3565	26·5	16·10	
4	1·3590	26·5	17·65	
5	1·3603	26·8	18·27	
6	1·3615	27·0	19·18	
7	1·3608	27·0	18·78	
8	1·3608	27·0	18·78	
9	1·3610	27·0	18·88	
10	1·3615	27·0	18·88	
11	1·3615	27·0	18·88	
12	1·3615	27·1	18·88	
13	1·3624	27·1	19·73	
14	1·3624	27·2	19·74	
15	1·3625	27·2	19·79	
16	1·3630	27·3	20·09	
17	1·3615	27·4	19·20	
18	1·3615	27·5	19·21	
19	1·3615	27·5	19·21	
20	1·3610	27·6	18·94	
21	1·3600	27·6	18·31	Half dead leaf.
22	1·3605	27·6	18·61	
23	1·3615	27·7	19·22	
24	1·3605	27·8	18·63	Highest dead leaf.
25	1·3598	27·8	18·18	
26	1·3598	27·8	18·18	
27	1·3585	27·8	17·43	
28	1·3575	27·8	16·78	
29	1·3564	27·8	16·08	
30	1·3545	28·0	14·95	Lowest fully green leaf.
31	1·3545	28·0	14·95	
32	1·3505	28·0	12·30	
33	1·3485	28·0	11·05	

TABLE 11.—(*Contd.*)

No. of internode from base	Observed n D	Observed temp. °C.	Total solids calculated as sugar at 28°C. %	REMARKS
		YUBA.		
1	1·3497	28·6	11·84	
2	1·3488	28·8	11·31	Late cane. Immature.
3	1·3490	28·9	11·46	
4	1·3510	29·0	12·72	
5	1·3510	29·0	12·72	
6	1·3523	29·0	13·57	
7	1·3540	29·0	14·72	
8	1·3530	29·0	14·07	Highest dead leaf.
9	1·3523	29·0	13·57	
10	1·3520	29·0	13·37	
11	1·3505	29·0	12·37	
12	1·3505	29·0	12·37	
13	1·3505	29·0	12·37	Lowest fully green leaf.
14	1·3485	29·0	11·12	
15	1·3465	29·0	9·77	
		SARETHA.		
1	1·3595	29·2	18·13	Maturing.
2	1·3590	29·2	17·83	
3	1·3587	29·2	17·68	
4	1·3600	29·3	18·44	
5	1·3605	29·3	18·74	
6	1·3603	29·3	18·59	
7	1·3603	29·2	18·58	
8	1·3595	29·1	18·12	
9	1·3582	29·0	17·32	
10	1·3605	29·0	18·72	
11	1·3615	29·0	19·32	
12	1·3620	29·0	19·67	
13	1·3630	29·0	20·22	
14	1·3615	29·0	19·32	
15	1·3632	29·0	20·37	
16	1·3625	29·0	19·92	
17	1·3622	29·0	19·77	
18	1·3612	28·8	19·11	
19	1·3620	28·8	19·66	Highest dead leaf.
20	1·3620	28·8	19·66	Half dead leaf.
21	1·3615	28·8	19·31	Carried fully dead leaves.
22	1·3610	28·5	18·99	
23	1·3610	28·5	18·99	
24	1·3605	28·4	18·68	
25	1·3595	28·3	18·07	Fully green leaf.
26	1·3590	28·3	17·77	
27	1·3560	28·3	15·87	
28	1·3540	28·3	14·67	
29	1·3505	28·3	12·32	
30	1·3470	28·3	10·07	
		CHEN.		
1	1·3625	28·2	19·86	
2	1·3625	28·2	19·86	Cane maturing.
3	1·3620	28·2	19·61	
4	1·3622	28·4	19·72	

TABLE II.—(*Contd.*)

No of internode from base	Observed n D	Observed temp. C	Total solids calculated as sugar at 28°C. %	Remarks
		CHEN.—*Concld.*		
5	1·3622	28·5	19·73	
6	1·3622	28·3	19·72	
7	1·3625	28·3	19·87	
8	1 3623	28·3	19·77	
9	1·3615	28·3	19·27	
10	1·3610	28·2	18·97	
11	1·3615	28·3	19·27	Cane when cut open was found pitty.
12	1·3615	28·3	19·27	
13	1·3595	28·3	18·07	
14	1·3585	28·2	17·46	
15	1·3615	28·2	19·26	
16	1·3631	28·2	20·21	
17	1·3620	28·2	19·61	Highest dead leaf.
18	1·3605	28·0	18·65	
19	1·3600	28·0	18·35	
20	1·3600	28·0	18·35	
21	1·3575	28·0	16·80	
22	1·3545	28·0	14·95	
23	1·3525	28·0	13·65	Lowest fully green leaf.
24	1·3500	28·0	12·00	
25	1·3475	28·0	10·40	
		SARETHA II.		
1	1·3625	26·7	19·76	Maturing.
2	1·3645	26·8	20·96	
3	1·3643	26·9	20·87	
4	1·3625	27·0	19·78	Crack.
5	1·3622	27·0	19·63	
6	1·3629	27·0	20·03	
7	1·3632	27·1	20·23	
8	1·3635	27·2	20·39	
9	1·3646	27·4	21·06	
10	1·3646	27·4	21·06	
11	1·3645	27·5	21·01	
12	1·3645	27·5	21·01	
13	1·3635	27·7	20·43	
14	1·3632	27·7	20·28	
15	1·3638	27·8	20·64	
16	1·3652	27·8	21·44	
17	1·3635	27·9	20·44	Highest dead leaf
18	1·3635	27·9	20·44	
19	1·3628	27·9	20·04	
20	1·3628	28·0	20·05	
21	1·3605	28·0	18·65	
22	1·3610	28·0	18·95	
23	1·3610	28·0	18·95	
24	1·3590	28·0	17·75	
25	1·3590	28·0	17·75	Lowest fully living leaf.
26	1·3590	28·0	17·75	
27	1·3555	28·0	15·60	
28	1·3510	28·1	12.65	
29	1·3481	28·1	10·80	

TABLE 11.—(*Concld.*)

No. of internode from base	Observed n D	Observed temp. °C.	Total solids calculated as sugar at 28°C %	REMARKS
			BHAROKAH.	
1	1·3568	29·5	16·51	Cane maturing.
2	1·3566	29·5	16·36	
3	1·3565	29·5	16·31	
4	1·3565	29·5	16·31	
5	1·3565	29·5	16·31	
6	1·3560	29·5	15·96	
7	1·3545	29·5	15·06	
8	1·3545	29·5	15·06	
9	1·3545	29·5	15·06	
10	1·3550	29·5	15·36	
11	1·3535	29·5	14·41	
12	1·3545	29·4	15·05	
13	1·3545	29·2	15·04	
14	1·3543	29·2	14·94	
15	1·3537	29·2	14·54	
16	1·3545	29·2	15·04	
17	1·3540	29·2	14·74	
18	1·3550	29·2	15·34	
19	1 3555	29·1	15·68	
20	1·3560	29·1	15·93	
21	1·3565	29·0	16·27	
22	1·3570	29·0	16·57	
23	1·3575	29·0	16·87	
24	1·3565	29·0	16·27	
25	1·3580	29·0	17·17	
26	1·3583	29·0	17·37	
27	1·3563	29·0	16·12	
28	1·3555	29·0	15·67	
29	1·3545	29·0	15·02	
30	1·3535	28·9	14·37	Highest dead leaf.
31	1·3510	28·9	12·72	
32	1·3500	28·8	12·06	
33	1·3485	28·8	11·11	
34	1·3475	28·8	10·46	
35	1·3465	28·8	9·76	Lowest fully green leaf
36	1·3435	28·6	7·75	
37			No juice	
38			No juice	

Table III.

Showing results of refractometric examination of sugarcane varieties at regular intervals of one month during the period of their growth.

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %				No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	2-12-15	5-1-16	8-2-16	8-3-16		3-12-15	7-1-16	9-2-16	9-3-16
	B. 208.					**Yerra.**			
1	22·95	23·31	23·17	22·23	1	21·07	22·57	22·56	21·02
2	22·42	23·31	23·17	23·13	2	20·33	22·57	22·75	21·02
3	22·23	23·01	23·27	22·78	3	20·49	22·27	22·63	21·27
4	21·96	22·76	23·48	23·17	4	20·14	22·57	22·93	21·57
5	21·70	22·75	23·21	23·17	5	19·09	22·57	22·94	21·87
6	20·29	23·01	23·31	22·82	6	18·99	22·57	23·32	22·42
7	20·74	22·76	23·51	22·52	7	20·14	22·57	23·57	23·02
8	18·35	22·41	23·72	22·82	8	18·09	21·99	22·94	23·62
9		22·76	23·53	23·21	9		21·99	21·82	23·32
10		22·43	23·74	23·46	10		21·39	22·13	22·36
11		22·43	23·84	23·46	11			22·68	22·76
12		21·58	23·99	23·21	12			23·91	23·36
13		20·73	24·14	23·06	13			24·51	23·86
14			23·84	23·21	14			24·21	24·96
15			23·84	23·28	15			23·36	24·26
16			23·54	23·38	16				24·56
17			23·24	23·53	17				23·99
18				23·83					
19				24·13					
20				23·83					
21									

TABLE III.—(*Contd.*)

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %				No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	9-12-15	6-1-16	10-2-16	9-3-16		10-12-15	17-1-16	12-2-16	10-3-16
	MOGALI.					PURPLE MAURITIUS.			
1	19·79	21·67	20·80	20·43	1	19·64	23·34	23·32	23·10
2	19·80	21·69	20·80	20·73	2	19·38	24·02	23·92	22·85
3	19·32	21·69	21·38	21·08	3	20·05	24·04	24·22	22·50
4	17·52	21·69	21·39	21·32	4	19·85	24·04	24·52	22·85
5	18·12	21·39	21·69	21·62	5	19·78	24·07	25·12	22·70
6	18·12	21·12	21·99	21·93	6	19·38	26·11	25·67	22·52
7	16·12	20·52	22·26	21·93	7	18·59	27·01	26·31	22·39
8	16·27	20·52	22·26	22·23	8		27·27	27·21	22·54
9	16·27	20·52	22·26	22·24	9		27·03	27·46	22·91
10		20·52	22·57	22·23	10		27·03	27·76	23·17
11		20·52	22·57	22·23	11			27·21	24·07
12		20·52	22·93	22·48	12			26·91	24·41
13		20·52	23·21	22·78	13			26·31	25·01
14			22·84	22·68	14			25·41	25·59
15			22·23	22·93	15				26·19
16			21·54	23·13	16				26·79
17			21·02	23·13	17				26·19
18			19·86	23·13	18				25·93
19			19·86	23·38	19				25·29
20			19·86	22·78	20				25·04
21				22·19	21				24·44
22				21·89					

TABLE III.—(*Contd.*)

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %				No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	10-12-15	17-1-16	11-2-16	11-3-16		12-12-15	19-1-16	11-2-16	12-3-16
	RED SPORTS OF STRIPED MAURITIUS.					JAVA HEBBAL.			
1	18·42	18·71	20·13	20·10	1	20·78	17·85	18·61	19 23
2	18·70	18·65	20·32	20·27	2	20·20	21·35	19·86	19·88
3	18·40	19·28	20·42	20·07	3	19·92	21·35	20·11	19·88
4	17·92	19·28	20·43	20·07	4	19·93	21·35	20·41	19·53
5	17·67	19·64	20·73	19·82	5	20·83	22·51	20·71	19·57
6	17·55	19·86	21·08	19·50	6	20·83	22·52	21·31	19·31
7	17·55	19·26	20·73	19·85	7	19·71	21·37	21·61	19·31
8		18·36	21·08	20·10	8	19·71	22·89	22·09	19·61
9		18·96	21·33	20·40	9		22·24	22·42	19·96
10		19·85	21·63	20·40	10		21·71	22·21	20·21
11		20·80	21·93	20·70	11		21·41	22·47	20·51
12		20·15	22·33	21·08	12		21·38	23·76	20·21
13		19·25	22·78	21·33	13		21·38	23·07	20·51
14			22·48	21·08	14		20·83	23·36	20·81
15			22·23	20·73	15			23·14	21·16
16			21·63	21·08	16			22·76	21·45
17			21·08	21·33	17			22·42	21·71
18			20·33	21·08	18			21·87	22·31
19			19·88	21·63	19			21·57	22·90
20				21·93	20			21·27	23·25
21				22·48	21			20·67	23·50
2				22·78	22				23·80
23				23·42	23				
24				22·82	24				
25				22·31	25				

TABLE III.—(*Contd.*)

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %				No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	18-12-15	20-1-16	17-2-16	17-3-16		22-12-15	20-1-16	18-2-16	16-3-16
	MAJORAH.					KARIA.			
1	18·06	18·55	18·62	18·63	1	17·63	..	18·63	18·78
2	17·97	18·55	18·62	18·63	2	17·02	18·61	18·63	19·08
3	17·67	18·25	18·63	18·63	3	16·90	18·93	19·23	19·38
4	17·93	18·55	18·93	18·63	4	17·05	19·25	19·78	19·68
5	18·18	18·28	18·93	18·63	5	16·75	19·85	19·78	20·03
6	18·28	17·98	19·23	18·63	6	16·15	20·15	20·23	20·31
7	16·93	17·98	18·93	18·44	7	16·48	21·05	20·43	20·61
8	15·84	17·71	19·23	18·34	8	16·13	21·05	20·43	20·31
9	15·88	17·71	19·22	18·04	9	15·88	21·35	20·73	20·06
10	14·95	17·72	19·52	17·94	10	15·88	20·80	21·08	19·45
11	14·62	17·74	19·31	17·77	11	14·58	19·85	21·33	19·75
12	14·62	17·75	19·49	17·77	12			21·63	20·35
13	14·35	18·05	19·88	18·07	13			21·33	20·65
14	14·03	18·35	19·53	18·17	14				20·95
15	13·71	18·05	19·23	18·37	15				21·30
16	13·22	17·75	19·49	18·67	16				21·85
17	12·12	17·10	19·84	18·97	17				
18		17·10	19·84	19·21	18				
19		16·50	19·94	19·31					
20		15·85	20·09	19·46					
21			19·84	19·61					
22			19·14	19·96					
23			19·14	20·21					
24				19·96					
25				19·61					
26				19·31					
27				19·01					

TABLE III.—(*Contd.*)

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %				No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	22-12-15	24-1-16	18-2-16	21-3-16		23-12-15	24-1-16	19-2-16	21-3-16
	KALUDAI BOOTHAN.					CHITTAN.			
1	19·28	19·71	20·13	22·09	1	21·51	23·80	23·62	23·47
2	18·69	20·56	20·43	22·38	2	21·41	24·70	24·22	23·20
3	19·28	20·59	20·73	22·38	3	22·04	24·40	24·22	22·97
4	18·97	20·58	21·08	22·38	4	22·48	24·40	24·55	23·24
5	18·07	19·98	21·07	22·38	5	23·10	24·10	24·25	22·99
6	17·47	20·56	21·32	22·68	6	22·85	24·38	24·55	22·65
7	17·48	20·52	21·31	22·68	7	22·51	24·17	24·66	22·35
8	17·45	20·84	21·59	22·42	8	21·99	24·34	24·35	22·65
9	16·50	21·12	21·59	22·76	9	21·08	24·32	24·55	23·06
10	16·50	19·92	21·89	22·48	10		24·60	24·83	23·32
11			22·09	22·23	11		24·90	24·92	23·63
12			21·89	22·23	12		24·30	25·12	24·08
13			21·29	21·93	13		23·40	25·37	24·55
14			20·69	22·46	14			25·02	24·89
15			20·09	22·78	15			24·82	25·19
16				23·12	16			24·22	24·59
17				22·47	17				23·39
18				21·92	18				22·79
19				21·33	19				22·24

TABLE III.—(*Contd.*)

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %				No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	23-12-15	25-1-16	25-2-16	24-3-16		23-12-15	25-1-16	24-2-16	23-3-16
	Fiji C.					Fiji B.			
1	22·92	22·71	22·94	23·01	1	22·30	24·61	24·36	24·47
2	22·92	23·31	22·94	23·01	2	22·29	24·61	24·74	24·18
3	22·92	22·71	23·29	23·11	3	22·17	23·74	24·44	24·21
4	22·93	23·31	22·94	23·11	4	22·02	24·07	23·14	23·91
5	22·28	22·41	23·36	23·21	5	21·72	22·59	23·84	24·21
6	21·73	22·41	23·36	23·36	6	21·12	22·97	23·54	23·91
7		22·41	23·15	23·36	7	20·87	22·63	23·84	23·61
8		21·86	23·36	23·61	8		22·33	24·14	23·36
9		21·26	23·61	23·61	9		21·79	24·44	23·01
10			23·81	23·81	10		21·49	24·74	22·71
11			23·36	23·61	11		21·49	25·14	22·46
12			22·61	23·91	12		21·49	25·59	22·16
13			22·16	24·31	13		21·19	26·24	21·55
14			21·86	24·81	14			25·89	21·85
15			21·56	25·41	15			25·59	21·55
16			20·96	24·51	16			25·04	22·15
17				23·91	17			24·44	22·45
18				23·91	18			23·84	22·75
19					19			23·54	23·60
					20			22·94	23·36
					21				23·91
					22				24·51
					23				24·81
					24				24·21
					25				23·61
					26				23·01
					27				22·71

TABLE III.—(*Contd.*)

No. of internode from bottom	Total solids calculated as sucrose at 28°C. %				No. of internode from bottom	Total solids calculated as sucrose at 28°C. %			
	29-12-15	26-1-16	26-2-16	March		30-12-15	28-1-16	25-2-16	March
		BODI.					YUBA.		
1	..	..	..	No juice could be extracted by the needle.	1	19·03	..	..	No juice could be extracted.
2	..	..	..		2	19·09	..	..	
3	15·63	..	..		3	19·74	..	..	
4	15·29	..	..		4	19·41	18·99	18·48	
5	15·01	17·82	..		5	19·09	18·09	18·18	
6	14·92	17·82	17·91		6	18·79	18·41	18·18	
7	15·02	18·15	18·11		7	18·79	18·42	18·22	
8	15·02	18·15	17·91		8	18·49	18·72	18·32	
9	15·02	18·18	18·25		9	19·39	19·02	18·18	
10	14·77	17·88	17·95		10	19·09	19·05	18·48	
11	14·37	17·58	18·15		11	18·79	19·35	18·78	
12	14·07	17·58	18·25		12	18·19	19·39	19·08	
13	15·02	17·88	18·00		13	18·19	19·09	18·78	
14	13·72	17·58	18·25		14	17·89	19·39	19·08	
15	13·78	17·89	18·40		15		19·74	19·38	
16	14·06	18·19	18·55		16		19·09	19·68	
17	14·36	18·19	18·55		17		19·09	20·03	
18	14·05	18·79	18·25		18		18·49	20·23	
19	14·03	19·09	18·25						
20	13·33	19·09	18·25						
21	12·66	19·39	18·25						
22	12·65	19·09	18·55						
23		18·49	18·55						
24		18·19	19·15						
25		17·49	19·45						
26			19·75						
27			19·30						
28			18·85						

TABLE III.—(*Contd.*)

CHENI.

No. of internode from bottom	Total solids calculated as sucrose at 28°C. % 31-12-15	27-1-16	4-3-16	March
1	16·02	17·55	19·23	No juice could be extracted in the fourth month.
2	16·02	17·20	18·93	
3	16·02	17·20	18·11	
4	15·40	16·90	18·75	
5	15·42	17·20	19·08	
6	15·07	17·52	19·08	
7	15·06	18·09	18·78	
8	14·09	18·39	18·97	
9	12·70	18·65	19·13	
10	12·10	18·95	19·30	
11		18·35	19·40	
12		18·05	19·30	
13		17·45	19·40	
14			19·75	
15			20·10	
16			19·45	
17			18·55	
18			17·60	
19				
20				
21				
22				

NARGORI.

No. of internode from bottom	Total solids calculated as sucrose at 28°C. % 30-12-15	29-1-16	6-3-16	March
1	19·91	..	..	No juice could be extracted.
2	18·26	..	..	
3	17·66	..	..	
4	17·66	..	..	
5	17·51	..	..	
6	17·31	17·59	..	
7	17·01	17·59	..	
8	16·98	17·24	17·52	
9	16·02	17·59	17·55	
10	16·37	18·19	17·55	
11	16·67	17·59	17·24	
12	16·01	17·24	17·24	
13	16·64	16·94	17·59	
14	17·59	16·94	17·80	
15	16·94	16·64	17·93	
16	16·34	16·84	17·94	
17	15·33	16·94	17·87	
18	15·32	17·24	17·97	
19	15·02	17·59	17·67	
20	14·69	17·94	17·87	
21	14·33	17·89	18·01	
22	12·92	18·19	18·00	
23	12·30	18·49	18·31	
24	10·40	17·89	18·48	
25	10·03	17·24	18·63	
26	9·04	17·59	18·78	
27		16·94	18·63	
28		15·99	18·93	
29			18·93	
30			19·13	
31			18·93	
32			18·63	

TABLE III.—(*Concld.*)

CHIN. (*Aligarh.*)

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. % 31-12-15	27-1-16	7-3-16	
1	19·25	..	..	No juice could be extracted.
2	19·25	..	..	
3	19·25	18·96	..	
4	19·61	19·26	..	
5	19·25	18·95	18·93	
6	19·85	19·25	18·93	
7	19·59	19·60	19·23	
8	19·59	19·85	19·53	
9	19·24	20·15	19·87	
10	19·59	19·85	19·51	
11	19·24	20·15	19·86	
12	19·24	20·45	20·11	
13	18·95	20·80	20·37	
14	18·65	20·45	20·22	
15		20·80	20·33	
16		20·15	20·03	
17		21·05	20·29	
18		20·80	20·29	
19			20·59	
20			20·94	
21			21·19	
22			21·49	
23			20·94	
24			20·29	
25			19·09	

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No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. % 24-12-15	25-1-16	24-2-16	25-3-16
1	21·51	21·90	21·88	21·72
2	20·95	21·88	21·58	21·22
3	20·70	21·27	21·60	21·12
4	20·35	21·01	21·60	21·72
5	19·78	20·35	21·30	21·75
6	19·63	19·78	21·30	21·17
7	19·18	19·43	21·05	20·59
8	20·40	19·15	20·72	19·74
9	16·50	19·15	20·43	19·09
10	16·20	18·83	19·71	18·23
11	15·85	18·83	19·91	18·53
12	15·85	18·48	19·56	18·27
13	14·91	18·23	19·27	18·27
14		18·23	18·67	17·32
15		17·63	18·36	17·02
16			18·11	16·42
17			17·46	15·82
18			17·06	15·82
19			16·41	15·82
20				16·07
21				15·47

THE EFFECT OF SALINITY ON THE GROWTH AND COMPOSITION OF SUGARCANE VARIETIES.

BY

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DURING 1913, in a portion of Block II (Fields Nos. 3, 12 and 13) of the newly acquired Cane-breeding Station, Coimbatore, some sugarcane varieties and seedlings were planted. Of the thick cane varieties, imported or local, many died, and the few that came up were very unhealthy with pale or yellow leaves, and had a stunted growth. The North Indian thin indigenous cane varieties came up better, but not to the standard expected (Plate IX). Our seedling canes too fared no better on this piece of land, though on a portion of Block I (Field No. 7) the same seedlings came up satisfactorily. To study the causes of the unsatisfactory growth of canes in Block II, and to find out what sort of varieties come up and what not, Field No. 3, as representing Block II, was set apart, and on small plots of it year after year some varieties and seedlings were grown under the same conditions as existed when the estate was taken over.

GROWTH OF CANES IN BLOCKS I AND II COMPARED.

As a result of our experiments during the years 1914–18, it may be stated that thick juicy varieties as a rule do not come up on Block II (Field No. 3). Below is given a list of varieties that failed to grow and of those that came up well.

ALKALINE PLOT, 1914-15, 7½ MONTHS OLD.

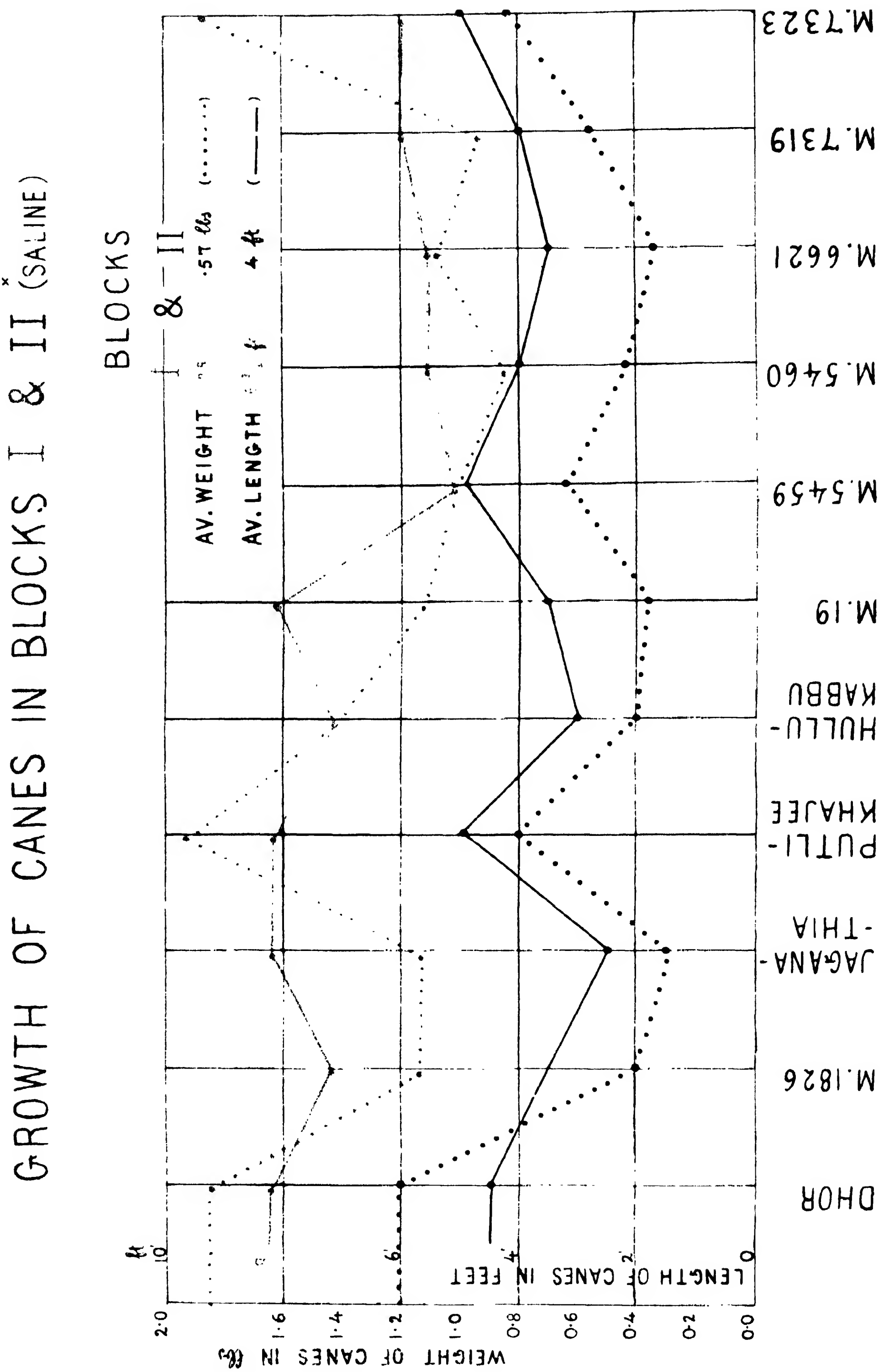
Kare Chittan K. Boothan Poovan J. 36 B. 208

Thick Canes

Che Naanal Teru Katha Chin Saretha

Thin Canes.

CHART I.



GROWTH OF CANES IN BLOCKS I & II (SALINE)
BLOCKS I & II
AV. WEIGHT .57 lbs (......)
AV. LENGTH 4 ft (——)
WEIGHT OF CANES IN lbs.
LENGTH OF CANES IN FEET
DHOR
M.1826
JAGANA-THIA
PUTLI-KHAJEE
HULLU-KABBU
M.19
M.5459
M.5460
M.6621
M.7319
M.7323

Block II (Field No. 3) irrigated by Well No. 3 (saline water).

VARIETIES THAT FAILED TO GROW.	THEIR GENERAL CHARACTERISTICS.
Karun, Chittan, Kaludai Boothan, Poovan, B. 208, Purple Mauritius, Magh, Bogapura, J. 36 and D. 74.	These are soft, thick canes containing from 10 to 15 per cent. of fibre, 15 to 20 per cent. of sucrose, and giving 65 to 75 per cent. of juice.
VARIETIES THAT CAME UP FAIRLY WELL.	
Cheni, Naanal, Katha, Saretha, Putli Khajee, Hullu Kabbu, M. 1017, Jagannathia, Dhor (Seoni), M. 1826, M. 19 and M. 2104.	These are harder, thinner canes, contain from 15 to 20 per cent. of fibre, 13 to 16 per cent. of sucrose, and give 40 to 55 per cent. of juice.

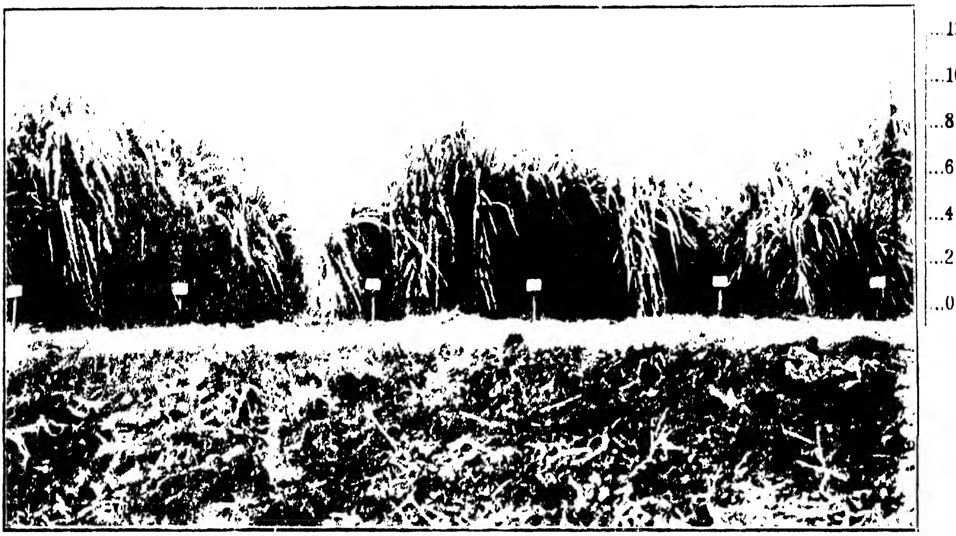
In order to make a detailed study of the differences in growth, etc., of canes in Block II (Field No. 3) and in Block I (Field No. 7), half a dozen varieties which had done well in Field No. 3 were chosen. They were planted and harvested on the same date on both the fields and their after-cultivation was also similar. The growth, etc., of the above varieties are hereunder compared. (Chart I.)

Variety	Block I					Block II				
	Stand	Length	Thickness	Av. wt.	Habit	Stand	Length	Thickness	Av. wt.	Habit
		ft.	cm.	lb.			ft.	cm.	lb	
Dhor (Seoni) ..	Full stand and medium vigour	8	2·35	1·80	Old canes curved, young canes straight	Nearly full and vigorous	4·5	2·20	1.20	Straight
M. 1826 ..	Full and rather vigorous	7	1·80	1·10	Straight below, and slightly curved at top	⅓ stand and medium vigour	3·5	1·80	0·40	Straight below, and slightly curved above
Jagannathia ..	Full and vigorous	8	1·75	1·10	Badly curved	Nearly full and medium vigour	2·5	1·65	0·30	Straight
Putli Khajee ..	Nearly full and medium vigour	8	2·30	1·90	Straight below, and curved at top	½ stand and fair vigour	5·0	2·30	0·80	Do.
Hullu Kabbu	Full and vigorous	7	2·00	1·40	Slightly curved	½ stand and medium vigour	3·0	not noted	0·40	Do.
M. 19 ..	Full and rather vigorous	8	1·65	1·10	Badly curved	½ stand and medium vigour	3·5	1·60	0·36	Do. but curved
ROGUES.*										
5459 ..	Full stand and vigour	5	2·00	1·0[illegible]		¾ stand and medium vigour	5·0	1·70	0·63	
5460 ..	Do. ..	5½	2·20	0·83		Do. ..	4·0	1·75	0·43	
6621 ..	Do. ..	5½	2·00	1·08		Do. ..	3·5	1·60	0·34	
7319 ..	Do. ..	6	1·90	0·94		Do. ..	4·0	1·65	0·56	
7323 ..	Do. ..	6	2·40	1·88		Do. ..	5·0	1·90	0·84	
AVERAGE ..	..	6¾	2·00	1·28		Do. ..	4·0	1·80	0·57	

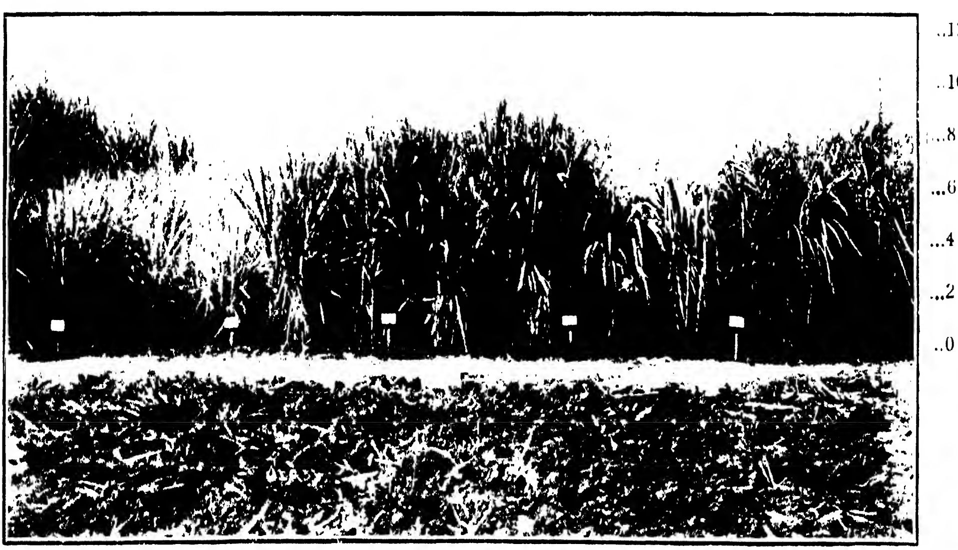
* Stray vigorous seedlings obtained from thick parents like Ashy and Striped Mauritius and Chittan and which are quite unlike their parents in vigour, etc.

PLATE X

SALINE PLOT (BLOCK II), 1915-16.

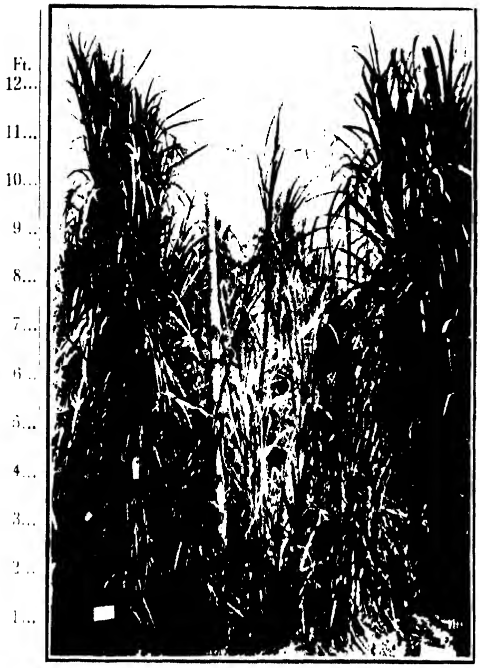


Kahi Saretha Nargori

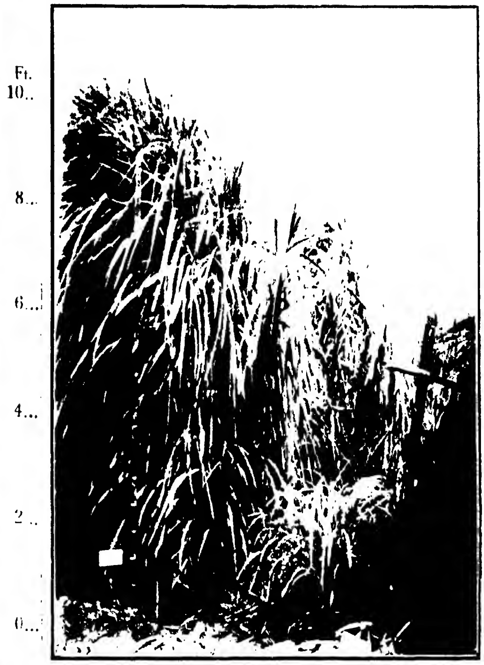


M. No. 21 M. No. 19 Putli Khajee Ekai Katha.

LESS SALINE PLOT (BLOCK I), 1915-16.



Saretha.



Chin.

Putli Khajee.

Katha.

From the above, it will be seen that cane varieties in Block I were one and a half times as tall and twice as heavy as those grown on Block II. In Block I the plants were more vigorous and had full stand, and, as already noted, thick cane varieties (Vellai, D.74, etc.) which do not come up at all in Block II come up in Block I satisfactorily. (Plates X and XI.)

Reasons for the differences in growth.

The reasons for the poor growth of cane varieties in Block II (Field No. 3) will be made clear if we compare the composition of the soil and irrigation water of that field with that obtained on Block I.

Analysis of soil and sub-soil of Blocks I and II.

	Block I		Block II	
	Surface soil	Sub-soil	Surface soil	Sub-soil
Cal. carbonate	0·018	0·009	0·018	0·018
Mag. carbonate	0·004	0·004	0·008	0·008
Sod. carbonate	0·001	0·008	0·003	..
Sod. sulphate	0·011	0·006	0·024	0·002
Sod. chloride	0·021	0·012	0·061	0·053
Total solids ..	0·085	0·070	0·170	0·140

Examination of layers of soil in pits dug in Blocks I and II.

	Block I	Block II
Soil	Fine red silt uniform throughout	Blackish, fairly stiff soil containing at a depth of about 2′ from the surface a hard layer of stiff soil incapable of free drainage.
Average percentage of chlorine in the 6 layers.	0·03	0·17
Average percentage of total solids in the 6 layers.		0·47

From the above analyses of soil, sub-soil and of pits, it will be seen that in Block II the percentage of sodium chloride in the surface

layers is more than three times that of Block I, and in deeper layers of pits it is worse still, containing nearly six times that of Block I. But for this sodium chloride, other salts present are not in any great excess in Block II.

Composition of well waters of Blocks I and II.

	Block I (Well No. 1)	Block II (Well No. 3)
	(In 100,000 parts of water)	
Cal. carbonate	21·42	26·80
Mag. carbonate	9·07	29·55
Sod. carbonate	10·39	....
Mag. sulphate	....	11·85
Sodium sulphate	10·37	48·16
Sodium chloride	32·58	188·98
Total solids (by evaporation) ..	91·00	342·00
Total injurious salts	53·34	248·99

The presence of 188·98 parts of sodium chloride in 100,000 parts is certainly very high and should have been the chief cause for the poor growth of canes observed in Block II (Field No. 3). It is observed in an article by the author on "well waters" in the *Madras Agricultural Students' Union Journal* (pages 26–28, January, 1914) that canes grown under a well containing more than 70 parts of sodium chloride at Saṃakulam Agrahāram were not doing so well as those which contained smaller quantities of the above salt. The evil effect of irrigating lands with such saline water, especially when the soil is fairly stiff as in Block II, is to produce an efflorescence of a peculiar kind of soft brownish earth, very powdery, on the sides and tops of ridges(*see* Text-figure). This kind of efflorescence was practically absent in Block I. The powdery earth was carefully scraped, sampled and analysed with the following result :—

Analysis of the saline efflorescence found in Block II.

	per cent.
Lime (CaO)	1·10
Magnesia (MgO)..	0·43
Potash (K_2O)	0·02
Carbonic acid (CO_2)	0·01
Sulphuric acid (SO_3)	0·57
Chlorine (Cl)	3·83
Nitrates (by Nitrometer)	0·43

The above analysis confirms that the chief cause for the bad growth of cane in Block II is chlorine.

Saline efflorescence in Block II.

It may be interesting to note in this connection that an analysis of the water that was dripping from the other end of cane on crushing, showed that 60 per cent. of the soluble ash was sodium chloride (*vide* page 390 (1915) of the *Madras Agricultural Students' Union Journal*).

If we now take into consideration all the above factors which go to smother the growth of cane in Block II (Field No. 3), it may be inferred that the chief source of all our troubles is the nature of irrigation water of Well No. 3, and that the chief injurious ingredient of this water is chlorine. Other contributory causes, *viz.*, saline nature of soil layers in pits, the very badly saline nature of the efflorescence, etc., may all be traced to this bad irrigation water. The indifferent drainage of Field No. 3, due to the presence of a hard stiff layer at a depth of about two feet, may have also contributed to the bad growth.

Effect of saline conditions on the ash of cane juices.

To determine how the saline conditions above referred to affect the composition of sugarcane juices, the following experiments were made. One hundred c.c. each of the juices of Cheni, Teru, and Katha varieties were evaporated to dryness and ignited. The quantities of inorganic salts found in the above are given below :—

Particulars	Varieties: Cheni	Teru	Katha
Lime	0·023	0·037	0·035
Magnesia	0·067	0·083	0·074
Phosphoric acid	0·079	0·059	0·081
Sulphuric acid	0·132	0·062	0·087
Chlorine	0·266	0·234	0·355
Potash	0·350	0·314	0·395
Undetermined	0·058	0·079	0·160
Total percentage of ash ..	0·975	0·868	1·187

The above analysis gives one an idea of the large percentage of chlorine in the juices of canes grown under saline conditions.

CHART II.

CHLORINE IN CANE JUICES OF BLOCKS I (—) & II (---) SALINE

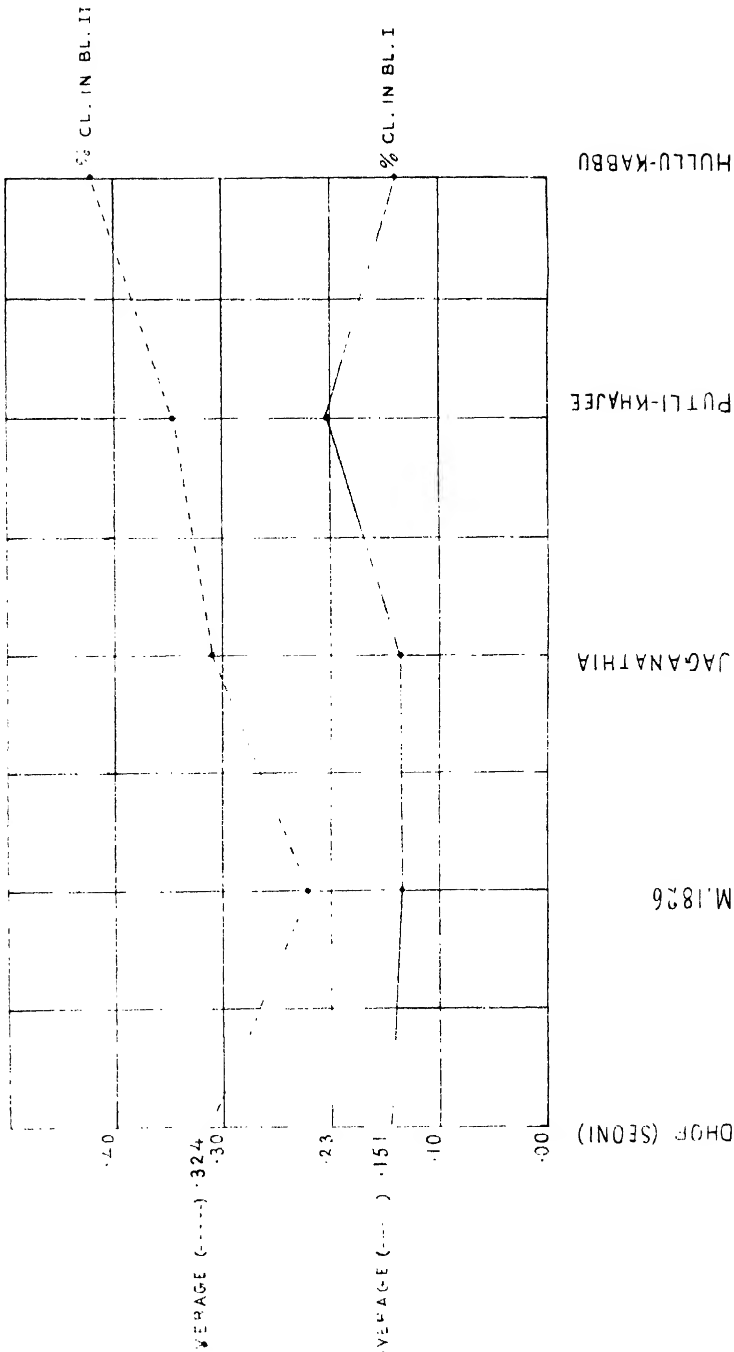
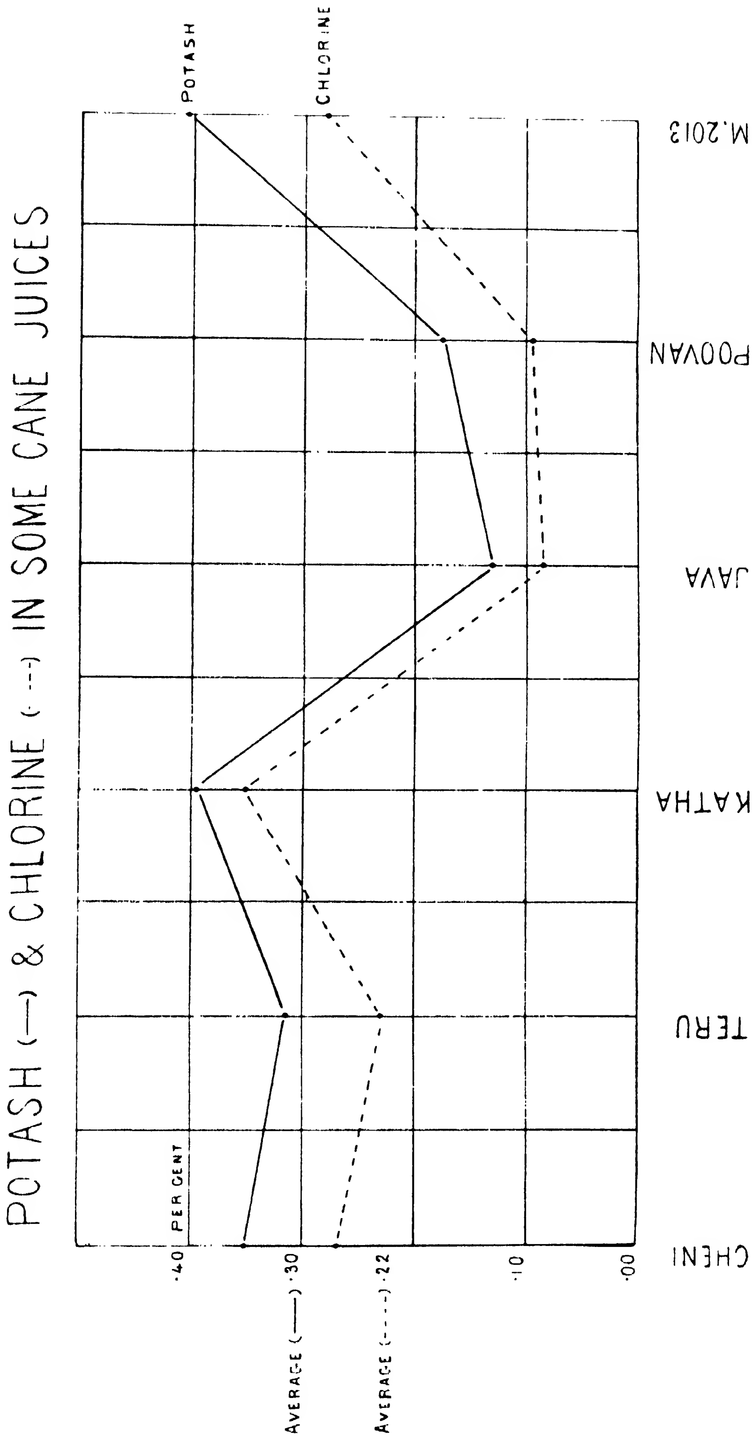


CHART III.



POTASH (—) & CHLORINE (---) IN SOME CANE JUICES
POTASH
CHLORINE
M.2013
POOVAN
JAVA
KATHA
TERU
CHENI
PER CENT
·40
·30
·22
·10
·00
AVERAGE (——) ·30
AVERAGE (----) ·22

How these same varieties would fare if grown under better conditions could not be ascertained, as we had no duplicate plot then. In the year 1917-18, as already noted, we had a duplicate plot of Block I. Below is given a comparison of the chlorine contents of the same varieties grown under different conditions (Chart II).

Varieties	Block I		Block II	
	Total solids	Chlorine	Total solids	Chlorine
Dhor (Seoni)	0·707	0·144	0·918	0·316
M. 1826	0·765	0·135	0·810	0·218
Jagannathia	0·846	0·136	0·959	0·313
Putli Khajee	0·955	0·204	1·073	0·346
Hullu Kabbu	1·039	0·138	1·139	0·426
Average ..	..	0·151		0·324

From the above it will be seen that the average percentage of chlorine obtained in the ash of cane juices of varieties grown under saline conditions is more than double that obtained in the duplicate plot (Block I). Again, a reference to the detailed analysis of ash shows that juices which are highly charged with chlorine also contain a high percentage of potash (Chart III).

	Chlorine	Potash
Cheni	0·266	0·350
Teru	0·234	0·314
Katha	0·355	0·395

Figures of further analyses made to confirm the above results are—

Java	0·088	0·14
Poovan	0·095	0·18
M. 2013	0·280	0·41

The presence of chlorine in the juices, as already mentioned, is due to the large amount of that element in irrigation water and in the soil. But the presence of large percentages of potash in the juices is not so easily explained. Fortunately, this question has been tackled by Geerligs (page 586, *Inter. Sugar Journal*, 1905), and his investigations on the influence of soda salts on the constitution of sugarcane afford the necessary explanation. His conclusions are :

"From these investigations we draw the conclusion that sodium chloride extracts potash, lime and magnesia from the soil, and puts these at the disposal of plants; and next, that sugarcane assimilates in the first place the potash, in a much inferior degree lime and magnesia, and finally, if there is nothing else to be had, also soda, etc." Thus the presence of potash in a marked degree in the juices of canes grown under saline conditions has been traced to be due to sodium chloride present in large quantities in irrigation water and in the soil, and as large quantities of potash co-exist with large quantities of chlorine, it suggests itself that an analysis of any one of the above ingredients may give one an idea of the quantity of the other.

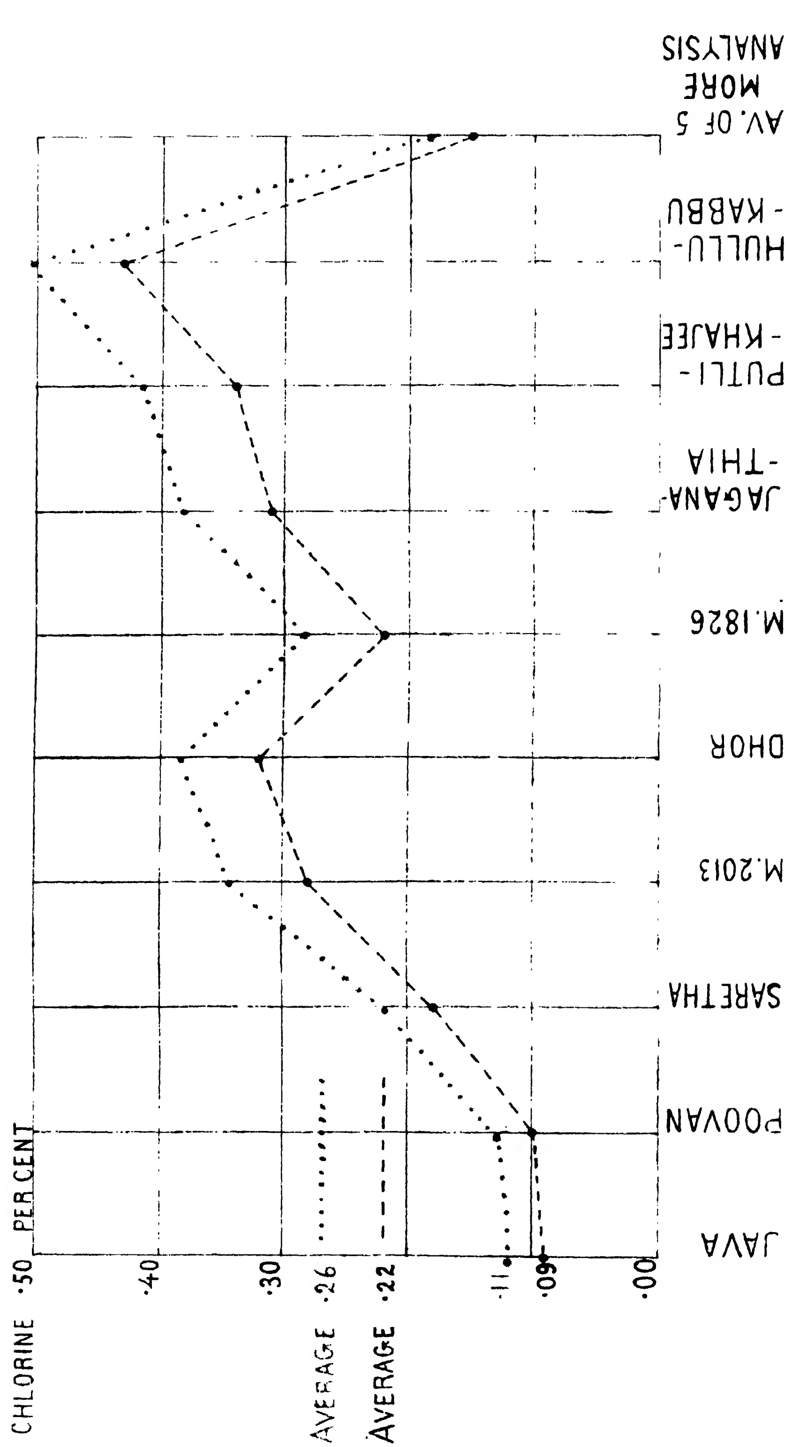
The determination of potash is not easy and entails tedious processes; so the choice fell on chlorine. Even in this, the usual method of determination—evaporating the juice to dryness, igniting the same and then titrating the water extract against silver nitrate solution—is not quite feasible in an ordinary field laboratory. Again, as sugarcane juices are generally acid in reaction and also turbid, without neutralization and clarification, a sharp end reaction with silver nitrate solution cannot be obtained. The usual basic lead acetate cannot be used for clarification purposes, as chlorides present in the juice will be precipitated as lead chloride. After many trials, the following method that is found to give fairly satisfactory results was adopted.

Direct method of determining chlorine in cane juices.

Fifty c.c. of the sugarcane juice to be examined were measured out into a 100 c.c. measuring flask, neutralized with pure lime water, 25 c.c. of alumina cream added, and the whole then made up to 100 c.c. with distilled water. This was then transferred to a beaker and kept covered on a sand bath for some time till albuminoids, etc., in the juice began to coagulate and settle down. On filtration the filtrate was found to be clear and ready for titration. For impure juices a small quantity

CHART IV.

CHLORINE BY ALUMINA CREAM (.....) AND IGNITION (- - -) METHODS



of bone char may be necessary to ensure a clear filtrate. Twenty-five c.c. of this filtrate—equivalent to 12½ c.c. of the original juice—were taken and titrated against decinormal silver nitrate solution.

The above method of determining chlorine directly in the juice saves much time and can be undertaken side by side with the usual juice analysis in any field laboratory where facilities for evaporating and igniting the juice do not exist. Though this method gives slightly higher percentages than that obtained by the ignition method, as will be seen hereafter, the results obtained give one a correct idea of the relative quantity of chlorine in the juice—the main object aimed at.

The usual ignition method and the alumina cream method compared.

To ascertain the differences in the value of chlorine obtained in the two methods, it was determined by the usual evaporation and ignition method at the chemical laboratory by one assistant, and by the lime water alumina cream method at the Cane-breeding Station field laboratory by another with the following result (Chart IV):—

Chlorine obtained in 100 c.c. of cane juice.

Variety	Ignition method	Alumina cream and lime water method
Java	0·090	0·110
Poovan	0·095	0·120
Saretha	0·180	0·210
M. 2013	0·280	0·340
Dhor (Seoni)	0·316	0·381
M. 1826	0·218	0·285
Jagannathia	0·313	0·366
Putli Khajee	0·346	0·408
Hullu Kabbu	0·426	0·500
Average of a set of another 5* analyses of the above varieties in the duplicate plot.		
* Dhor (Seoni), M. 1826, Jagannathia, Putli Khajee, Hullu Kabbu.	0·151	0·179
Average of all the above..	0·216	0·258

It is seen that the percentage of chlorine obtained from the ignition method is about 16 per cent. less than that obtained

by the alumina cream method. As the ingredients used were pure, it is presumed that this may be due to the loss of a small quantity of chlorine in the ignition method by volatalization, and to the precipitation of some other substances of the cane juice by silver nitrate in the direct method.

Having traced the poor growth of cane in Block II (Field No. 3) to be due to the very badly saline conditions under which they were grown, and having shown that such canes contain in their juices large percentages of chlorine, it is now proposed to compare in a general way the amount of chlorine which the different varieties are capable of taking from the soil and the effect of chlorine on the sucrose, glucose, and purity of the cane juices.

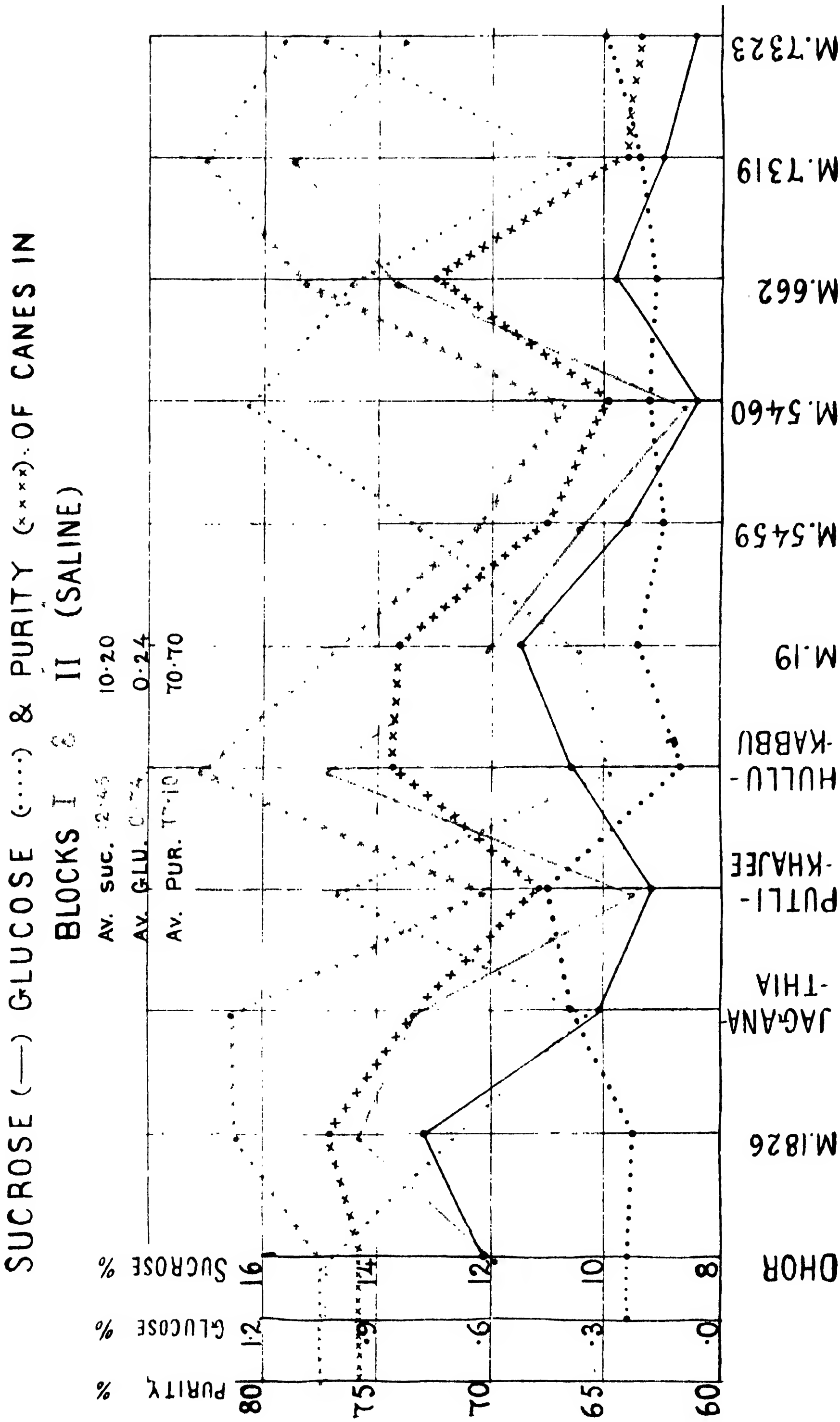
THE AMOUNT OF CHLORINE ABSORBED BY DIFFERENT VARIETIES AND ITS EFFECT ON THE SUCROSE, GLUCOSE, ETC., OF CANE JUICES.

Chlorine contents of good thick juicy varieties under saline conditions obtained in Block II could not be estimated, as they do not grow at all under such conditions. But to show in a rough way that they are not capable of absorbing much chlorine, I give below some chlorine results of thick cane seedlings grown on Block I.

Thick cane seedlings and varieties.

Variety	Seedling No.	Silver nitrate required for 100 c.c. juice (by the alumina cream method)	Chlorine in 100 c.c. of juice
Karun	1313	36·8	0·13
	1279	26·0	0·09
	885	30·0	0·11
	1170	35·2	0·12
	1173	36·0	0·13
Chittan	485	27·2	0·10
	222	22·0	0·08
Java	....	....	0·09
Poovan	....	....	0·95
AVERAGE ..	....	30·5	0·11 This is equivalent to 0·09 by the ignition method.

CHART V.


SUCROSE (—) GLUCOSE (....) & PURITY (×××) OF CANES IN
BLOCKS I & II (SALINE)
Av. SUC. 10·20
Av. GLU. 0·24
Av. PUR. 70·70
% SUCROSE
16
14
12
10
8
% GLUCOSE
1.2
.9
.6
.3
.0
% PURITY
80
75
70
65
60
DHOR
M.1826
JAG-ANA-THIA
PUTLI-KHAJEE
HULLU-KABBU
M.19
M.5459
M.5460
M.662
M.7319
M.7323

Thin cane varieties.

Variety	Year	Remarks	Chlorine in 100 c.c. of juice
Cheni ..	1914	Block II (Fields Nos. 12 & 13). No duplicate plot. Chlorine got by the ignition method	0·266
Teru ..			0·234
Katha ..			0·355
Naanal ..	1915	Block II (Field No. 3). No duplicate plot. Chlorine by the alumina cream method	0·260
Cheni ..			0·330
Katha ..			0·350
Saretha ..			0·370
M. 1017 ..			0·420

As already noted, the amounts of chlorine absorbed by some North Indian thin cane varieties under saline and sweet water conditions are given below :—

Varieties	Block I (sweet water conditions)	Block II (F. No. 3 saline conditions)
	Chlorine	Chlorine
Dhor (Seoni)	0·144	0·316
M. 1826	0·135	0·218
Jagannathia	0·136	0·313
Putli Khajee	0·204	0·346
Hullu Kabbu	0·138	0·426
Ave age of all thin canes ..	0·151	0·340

From the above it could be roughly inferred—

(1) that thick juicy cane varieties absorb much less chlorine than thin hardy varieties;

(2) that chlorine contents of varieties to a great extent depend upon the nature of soil and of irrigation water under which they are grown;

(3) that different varieties absorb different amounts of chlorine though grown under the same conditions.

From the figures given in the following tables it will be seen that the effect of large quantities of chlorine in any juice is to lower the values of sucrose, purity, as well as of glucose (Chart V).

Sucrose.

Year	Seedling No. or variety	Block I	Block II
1913–14	17 ..	14·71	12·24
	19 ..	15·31	14·14
	25 ..	14·20	11·86
	26 ..	11·75	10·88
	27	14·76	11·96
	29	14·62	9·79
	30	14·14	15·99
	34 ...	14·79	10·49
	37 ...	11·68	9·84
	38 ..	15·84	13·42
	45 ..	16·19	14·57
	AVERAGE ..	14·36	12·29
1917–18	Dhor (Seoni)	11·78	12·11
	M. 1826	14·15	13·16
	Jagannathia ..	13·33	10·08
	Putli Khajee	9·40	9·23
	Hullu Kabbu ..	14·83	10·64
	M. 19	11·99	11·53
	5459	10·44	9·65
	5460	8·46	8·45
	6621	13·60	9·84
	7319	15·39	9·05
	7323	13·54	8·44
	AVERAGE ..	12·45	10·20

Out of 22 cases considered, in 20 cases the sucrose percentage is higher in the less saline plot (Block I) and the average percentage is higher by 2 per cent.

Glucose and co-efficient of purity.

Varieties and rogues	Block I		Block II	
	Glucose%	Purity	Glucose%	Purity
Dhor (Seoni)	1·02	77·0	0·23	75·5
M. 1826	0·70	80·8	0·22	76·9
Jagannathia	0·32	81·3	0·40	73·1
Putli Khajee	0·98	70·4	0·45	67·8
Hullu Kabbu	0·27	82·6	below 0·15	74·3
M. 19	0·36	76·6	0·21	74·2
5459	0·77	70·4	0·15	67·6
5460	1·22	66·7	0·19	64·8
6621	0·97	77·8	0·17	72·5
7319	0·38	82·3	0·21	63·9
7323	1·14	78·9	0·30	63·3
Average ..	0·89	77·1	0·20	70·7

It is natural to expect juices which contain larger amounts of soluble salts and which give lower sucrose results to give lower co-efficients of purity. But the lower percentage of glucose obtained in Block II was not quite expected. On the manufacturing side the effect of this low percentage of glucose in a juice which also contains large quantities of soluble salts is undesirable; for this condition would prevent crystallization of sucrose according to the researches conducted by Geerligs (*vide* pages 369 and 415, *Sugarcane*, 1895). This is due possibly to the large amount of soluble salts in the thin cane varieties with low percentages of glucose. The *jaggeries* obtained at the Cane-breeding Station do not set well and run to liquid in course of time.

Experiments with gypsum were conducted in 1916-17 with the varieties mentioned below under saline (No. 3 well water) and sweet water (No. 1 well water) conditions. Both the plots were planted between the 30th June and 3rd July, 1916, and both harvested between 28th June and 30th June, 1917. As the analytical results obtained confirm the previous results, they are noted below.

Variety	Sweet water conditions				Saline conditions			
	Av. wt.	Suc.	Glu.*	Purity	Av. wt.	Suc.	Glu.*	Purity
Putli Khajee ..	0·70	11·06	0·91	72·6	0·32	8·15	0·16	61·1
M. 19 ..	0·47	15·66	0·24	83·2	0·19	10·75	0·13	69·1
Hullu Kabbu ..	0·81	16·71	0·23	84·4	0·33	11·36	0·25?	70·9
Ekai ..	0·55	12·17	0·39	78·9	0·25	5·78	0·10	51·0
Dhaur Kinar ..	0·32	15·26	0·28	81·2	0·22	9·07	0·10	63·6
AVERAGE ..	0·57	14·17	0·41	80·0	0·26	9·02	0·15	63·1

* The glucose figures are the average of several determinations. The figures for individual cases are given below and they prominently bring out the fact of very low results obtained under saline conditions.

Putli Khajee ..	1·03	0·68	1·14	& below 0·81	below 0·15	below 0·15	0·18	0·24
M. 19 ..	0·28	0·25	0·34	& below 0·15	below 0·15	below 0·15	below 0·15	0·23
Hullu Kabbu ..	0·18	0·31	0·37	& below 0·15	below 0·15	below 0·18	below 0·15	0·65?
Ekar ..	0·48	0·46	0·37	& 0·25	below 0·15	below 0·15	& below 0·15	..
Dhaur Kinar ..	0·43	0·26	0·25	& 0·20	below 0·15			

From the above, it will be seen that out of 20 determinations only two gave below 0·15 per cent. of glucose under sweet water conditions; whereas the same varieties under saline conditions gave below 0·15 of glucose in 11 out of 16 determinations.

REFERENCES TO LITERATURE ON THE SUBJECT.

Geerligs: "Generally in sugar mills where chiefly a pure and rich cane is crushed the juices contain little potash, while in others, where even the best ripened canes never rise above a comparatively low figure, large quantities of that element are to be found."—(*Inter. Sugar Journal*, page 420, 1911.)

Hilgard: "The common beet (including the Mangel Wurzel) is known to succeed on saline seashore lands........Such beets are wholly unfit for sugar-making. They are also said to be bitter for stock."—(*California Bulls. 128 and 133.*)

Lehman: " Alkaline nature of a soil gives greater soluble ash in canes which prevent sugar crystallizing out, and it makes the sugar content also low."—(*Mysore, Third Annual Report.*)

Hilgard: " In grapes the sugar content seems to have throughout the tendency of decreasing with increasing strength of alkali."—(*California Bulls. 128 and 133.*)

Leather: " The taste of the cane was distinctly saltish, showing that it is a salt-absorbing plant—a fact of some practical value. It may be remarked that the presence of any large quantity of these salts in cane juice would make it useless for manufacturing purposes. The percentage of sugar in the cane appears to be below the average."—(*Agri. Ledger*, 1901.)

Mann: " Sugarcane, when well manured and watered, is a crop very resistant to damage by salt, and, as a rule, when it will not grow, the land can be used for little else."—(*Bom. Bull. 39* of 1910.)

Note.—The above statement of Mann is rather exaggerated as we have been getting at the Cane-breeding Station good crops of *cholam* (*Sorghum*) and *ragi* (*Eleusine coracana*) in Block II (Field No. 3), where good thick canes do not come up at all, and where even the thin hardy canes only grow indifferently.

The results of experiments by Echart at Hawaii regarding the effect of salt in the irrigation waters are given below:—

Plot No.	Salt per gal. in irri. water	Lime added	Grs. of Cl. per gal. in juice	Sugar per acre
				lb.
1	None	No lime ..	9·80	25,648
2	200 gr.	Coral (powdered)	93·10	5,448
3	200 „	Gypsum ..	84·90	5,461
4	200 „	No lime ..	105·24	3,715

Note.—200 gr. in a gallon is equivalent to 286 parts in 100,000 parts of water.

100 gr. of chlorine per gallon is equivalent to 0·143 gr. of chlorine in 100 c.c. of juice, or equivalent to the amount of chlorine precipitated in 100 c.c. juice by about 40 c.c. of decinormal silver nitrate solution.

From the above, it is seen that in a variety of cane containing about 100 grains of chlorine in a gallon of juice the outturn of sugar

per acre is very much reduced. Also the application of lime or gypsum to lands irrigated by saline waters has had very little effect either on the chlorine content or sugar per acre. The results obtained on the Cane-breeding Station with gypsum go to confirm the above statement.

Low quality jaggery obtained from North Indian canes at the Cane-breeding Station explained.

Our experience on the manufacturing side, *i.e.*, making *jaggery* from juices containing chlorine, are in conformity with the opinions expressed above. In a general way, it may be stated that on fields where the chlorine percentage is low, *e.g.*, Fields Nos. 9 and 24, we have been able to grow successfully thick cane varieties and have prepared from them fairly good *jaggery*. In other fields which were for a long time under saline irrigation before they were taken up by the Government Sugarcane Expert, the good varieties and seedlings which did not come up at all in 1913 are now coming up fairly well under sweet water irrigation and other improved methods of cultivation. The North Indian varieties and thin seedlings which were coming up indifferently before are coming up well now. But the *jaggery* obtained from North Indian cane varieties is still unsatisfactory. This shows that obtaining good quality *jaggery* does not depend upon the successful growth of canes only. The explanation for our getting unsatisfactory *jaggery*, especially from Fields Nos. 12 to 20, appears to be that those fields still contain in the surface or deeper layers of soil fairly large amounts of chlorine, and that North Indian varieties which have been shown to be more capable of absorbing chlorine than thick cane varieties take up sufficient chlorine to lower the quality of their juices and consequently give inferior kind of *jaggery*.

Summary.

Summarising the above it is found that—

(1) Soft, thick, juicy varieties do not come up at all in saline land (Block II, Field No. 3), while, thin hard and less juicy varieties come up fairly well.

(2) Sugarcane varieties and seedlings, which do not come up well under saline conditions (Block II), come up far better under less saline conditions (Block I), and this difference in growth is traced to be due chiefly to sodium chloride.

(3) The effect of saline irrigation is to give an impure juice containing large amounts of chlorine and potash, and that a determination of chlorine alone, which is comparatively easy, will give one an idea of the approximate quantity of the other.

(4) The usual method of determining chlorine—evaporating the juice, igniting the same and determining chlorine in the water extract—not being found quite feasible in a field laboratory, a new method of directly determining chlorine in the juice by lime water and alumina cream is suggested. This is found to give a correct idea of the relative quantity of chlorine in juices, and is also quicker and better adapted to a field laboratory.

(5) The chlorine content of a variety depends upon (*a*) conditions of soil, water, etc., under which it is grown, (*b*) nature of the variety itself.

(6) The effect of large quantities of chlorine in any juice is to lower the sucrose, purity, and glucose contents of that juice.

(7) A large percentage of soluble salts in the juices of canes grown under saline conditions is usually associated with a low glucose content and interferes with the crystallization of sucrose.

(8) The inferior kind of *jaggery* obtained on the Cane-breeding Station from North Indian cane varieties is due, among other factors, to the high chlorine content of the juices. Determination of chlorine in the juice would give one an indication of the relative quality of *jaggery* one is likely to get.

In conclusion, I beg to offer my grateful thanks to Dr. C. A. Barber, C.I.E., for giving me every facility and for guiding me with suggestions during the course of this investigation.

PROBABLE MATERIAL FOR THE STUDY OF THE EXPERIMENTAL EVOLUTION OF *ORYZA SATIVA*, VAR. *PLENA*, PRAIN.

BY

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Oryza sativa, var. *plena,* Prain, the "double grain paddy," is a variety of rice cultivated in Bengal. Agriculturally it cannot be said to be a desirable variety, but it nevertheless possesses an interesting botanical curiosity. This consists in the fact that though practically to all outward appearances it looks like an ordinary variety of rice (Plate XII, fig. 1), still usually a certain proportion of the spikelets in the panicle, instead of having a solitary grain, may contain two to five grains or so each. This is due to the fact that nearly every spikelet in the panicle contains two to five ovaries in the flowering stage (Plate XII, fig. 3). The number of well developed grains per spikelet, however, is often one to three only, as probably all the ovaries are not in a fit condition to be fertilized at once or, even if they are, there is scarcely room enough for them to be properly developed. This variety is not grown in the Bombay Presidency.

In a plot of this variety, grown at Alibag for the first time this year, it was found, in rare instances, that the topmost spikelets on a few branches of the panicle had only a single ovary with four or more stigmas, two or more ovaries being then united together. The number of stamens in each spikelet is usually six, but in rare instances it was found to be seven or eight, thus indicating a slight tendency in the stamens to increase their number. In a few instances.

EXPLANATION OF PLATE XII.

Oryza sativa.

Fig. 1. Normal external appearance of a spikelet of an ordinary variety of rice.

„ 2. Contents of the spikelet of the same during flowering.

„ 3. Contents of the spikelet of the double grain paddy of Bengal. See the number of ovaries.

„ 4. Raw spikelet of an ordinary variety showing one of the empty glumes much elongated.

„ 5. A. Spikelet of an ordinary variety showing an additional empty glume.
B. Continuation of the additional empty glume from the side of the pedicel.

„ 6. A. Side view of the spikelet of an ordinary variety showing the fusion of the additional empty glume with the normal empty glume.
B. Diagrammatic representation of same.

„ 7. Spikelet of an ordinary variety showing additional flowering glume and pale which are rudimentary.

„ 8. Another spikelet showing more developed additional flowering glume and pale.

„ 9. Spikelet of an ordinary variety showing the doubling of the flowering glumes. Note the full development and the two awns.

„ 10. Diagrammatic representation of the spikelet in fig. 7 showing free pales and two rudimentary ovaries.

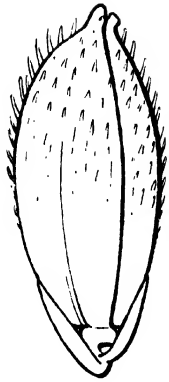


Fig. 1.

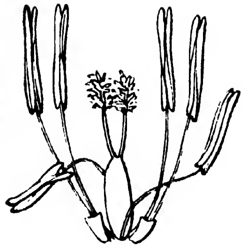


Fig. 2.

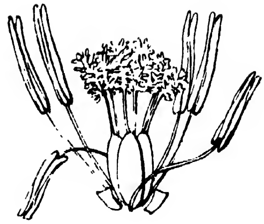


Fig. 3.

Fig. 4.

Fig. 5.

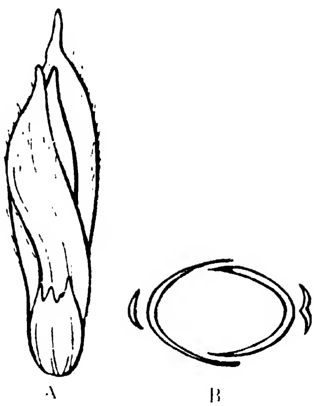


Fig 6.

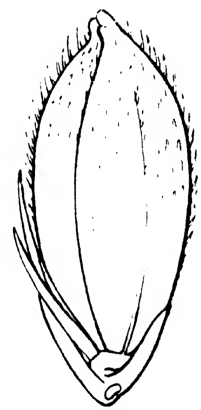


Fig. 7.

Fig. 8.

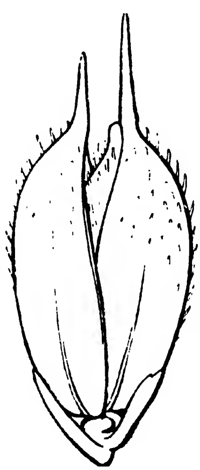


Fig. 9.

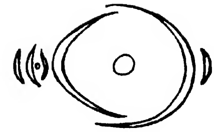


Fig 10.

ORYZA SATIVA.

the spikelets showed even a tendency to increase the flowering glumes and pales. A few plants were also found to show a slight tendency to form clusters of spikelets near the tips of the branches, as found in the two varieties described next.

One of these varieties, which is grown in the Central Provinces, is worth considering in this connection. This variety is called "cluster." Its peculiarity is that the tertiary branches of the panicle, instead of being elongated as in the ordinary variety, are shortened. with the result that at their tips the spikelets are brought very close together, so as to give the appearance of clusters carried at different points, on the secondary axis. This variety also is not generally grown in the Bombay Presidency.

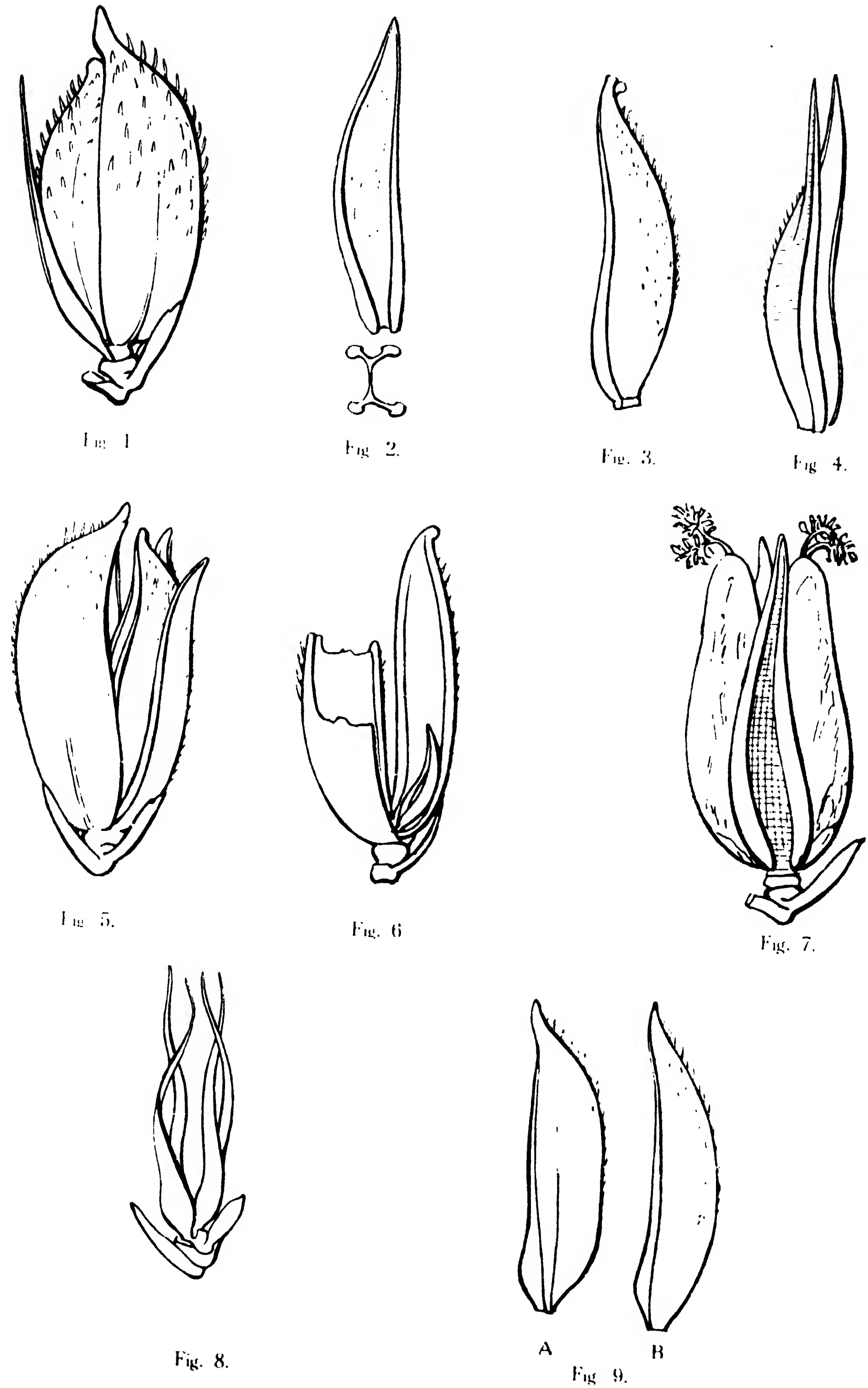
At Alibag, in a plot of this variety also, as in that of the above, a tendency to have additional flowering glumes in some spikelets has been noticed in rare instances. Thus, both these varieties seem to have a tendency to imitate each other.

There are a few varieties of rice in this Presidency which may be said to stand about half way between the cluster and the ordinary variety of rice. In these, instead of large clusters placed at different points on the secondary axis, each secondary and tertiary axis has only a small cluster made up of two spikelets, just at its tip. This is brought about by the shortening of the axis or the pedicel of the topmost spikelet on each branch. and the approximation of that spikelet to the lower one.

In one of these varieties also, a tendency to have larger clusters placed irregularly anywhere in the panicle was noticed in a few cases this year.

It may not be out of place to mention here that in a cross between an ordinary variety and the "cluster" the F_1 plant has small clusters near the tips of the secondary branches only. But in later generations we get not only "clusters," "ordinaries," and "small clusters at tips," but also some intermediate types. But in the variation obtained in the rare instances mentioned above, crossing was quite out of the question.

It is needless to describe the ordinary variety of rice except for showing how the different parts of the spikelet stand in relation



ORYZA SATIVA.

these processes are much reduced. A flowering glume is sometimes transformed into a pale by the loss of its lateral nerves. Such an organ is sometimes intermediate between a flowering glume and a pale. Because then it shows a lateral nerve as in the flowering glume on one side only and not on the other as in Plate XIII, fig. 9A.

4. The number of stamens may sometimes increase.

5. The number of ovaries may sometimes be doubled as in Plate XIII. fig. 7. accompanied by the doubling of the flowering glume and pale.

6. The number of stigmas may increase without an apparent increase in the ovaries or the flowering glumes. Possibly this is due to the fusion of the ovaries.

Although some of these variations were noticed by me. from time to time, in different plots at Alibag, during the last 6 or 7 years, still, curiously enough, most of them were found to occur in a marked degree in last October in no less than 6 or 7 plots at that station. Most of these plots were grown from seeds obtained from the cultivators. These varieties are generally grown in the salt land along the creeks, though I had grown them in sweet land along with other plots. The following are the names of the varieties which showed the above-mentioned variations: (1) Morchuka or Dhok; (2) Morchuka; (3) Rata; (4) Kala Rata; (5) Dodda-Pandya; (6) Lumba sal; (7) the double grain paddy of Bengal. Of these the last two are grown in sweet land. No. 6 resembles the "cluster" of the Central Provinces.

In the variety called "Morchuka," out of about 100 plants some eight or ten plants showed a strong tendency in some spikelets to produce additional flowering glumes and pales, and sometimes ovaries also. They also showed the other variations mentioned above. Indeed the tendency to vary was so strong in them that in each plant of the abnormal kind about 10 per cent. of the spikelets showed the sportive nature. In very many instances however these sportive spikelets were sterile, though instances with one well developed grain were not hard to find. Instances with two well developed grains however are rare, though they are not altogether impossible to obtain. Although I cannot vouch for the perfect

purity of the seeds as they were obtained from the cultivators, still very probably this sportive tendency does not seem to be due to crossing. In fact, this year I could even see this tendency in several fields in the salt area though to a far less extent. And even then the percentage of abnormal spikelets in the panicles was scarcely two.

From the specimens which I have collected here for sowing, and from the accompanying drawings it will be seen that practically every part of the spikelet has a tendency to be doubled. Similarly, all the varieties described above show the tendency to form additional glumes, pales and ovaries. They also show a tendency to form clusters of spikelets where they did not exist before. Thus, they may be said to be more or less overlapping. Whether these overlapping variations are due to some temporary disturbance in the plants, caused by an abnormal season, or they are the beginnings of progressive changes, has yet to be proved.

But at least the large percentage of abnormal spikelets in the panicles found this year, in several plants and from several plots, points towards the latter possibility. It is likely that by these variations nature wants to effect some saving of material or to do more work with the same amount of material. Of course, the production of the additional flowering glumes, pales, stamens, etc., by the double grain paddy might be a retrograde step. But in the other varieties it is not so. In the "cluster" there appears to be some saving of the material of which the axis is made. In the doubling of the flowering glume and pale and of the ovaries, except in the case of the double grain paddy, there seems to be an attempt not only to save the material required for the axis, but also that required for the empty glumes, lodicules and stamens. In some cases in which the pale becomes somewhat reduced, a saving of some of the material required for it must also take place. Thus in all these doubling cases the tendency to vary seems to be for the purpose of producing a type in the end which can give more seed with the same amount of material. Such a type, as we see, is the double grain paddy grown in Bengal.

Would it not be possible, therefore, to make use of the variability in this particular direction and to help it on to that final end by selection? Or, is it merely a dream to expect so? It is just possible that it may turn out to be a dream. It may even lead to some interesting results, if properly followed up. My idea is that by growing a number of generations of the seeds obtained from the strongly sportive plants, and by selecting from them fertile spikelets with the said tendency, it may be possible in course of time to obtain plants resembling the double grain paddy of Bengal. It is true that some variations necessary to show a complete change from the ordinary variety to the pure double grain paddy have not yet been observed. Thus, I have not yet actually come across a case in an ordinary variety of rice in which only the ovaries have been doubled without the doubling of the flowering glumes and pales. Doubling of the number of ovaries accompanied by reduction and transformation of the glumes and pales can, however, be seen, and it is sufficient ground to hope that by examining a large number of sportive plants in flower we may come across the final stage. Unfortunately I could not examine a sufficiently large number of sportive plants in flower this year, but next year I hope to follow up that point more successfully. If we could only get the final stage once, there would be some hope of being in a position to bring about an experimental evolution of the double grain paddy from an ordinary variety without the help of crossing. I therefore intend to follow up this experiment for a few years.

SOME FOREIGN INSECT PESTS WHICH WE DO NOT WANT IN INDIA.

BY

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THE danger of introducing new insect pests of different kinds from foreign sources is, nowadays, so well recognized that in most advanced countries, especially where scientific agriculture has made some progress, a system of quarantine is strictly imposed on all articles of import which are likely to bring such pests into the country. Such State action would go a great way in checking the entry of alien insects, especially those which are known to be bad in other countries, and which, if allowed entry, might become a regular menace to agriculture. Well-known examples of unconscious introduction of undesirable animals into new lands are those of the rabbit into Australia, the mungoose into the West Indies, and the sparrow into the United States. When this has been the case even with higher animals much more are the chances favourable to lower animals and especially insects. With their small size, their powers of rapid multiplication, and their varied habits, insects stand very good chances of getting distributed from country to country.

Recognizing the above facts, the Government of India have also moved in the matter recently, and have passed what is called the Pests Act to protect the country from the invasion of foreign insect and fungus pests. Now that the Government have taken action in the matter, I think the present moment is not inopportune to see what the important foreign insect pests are which have

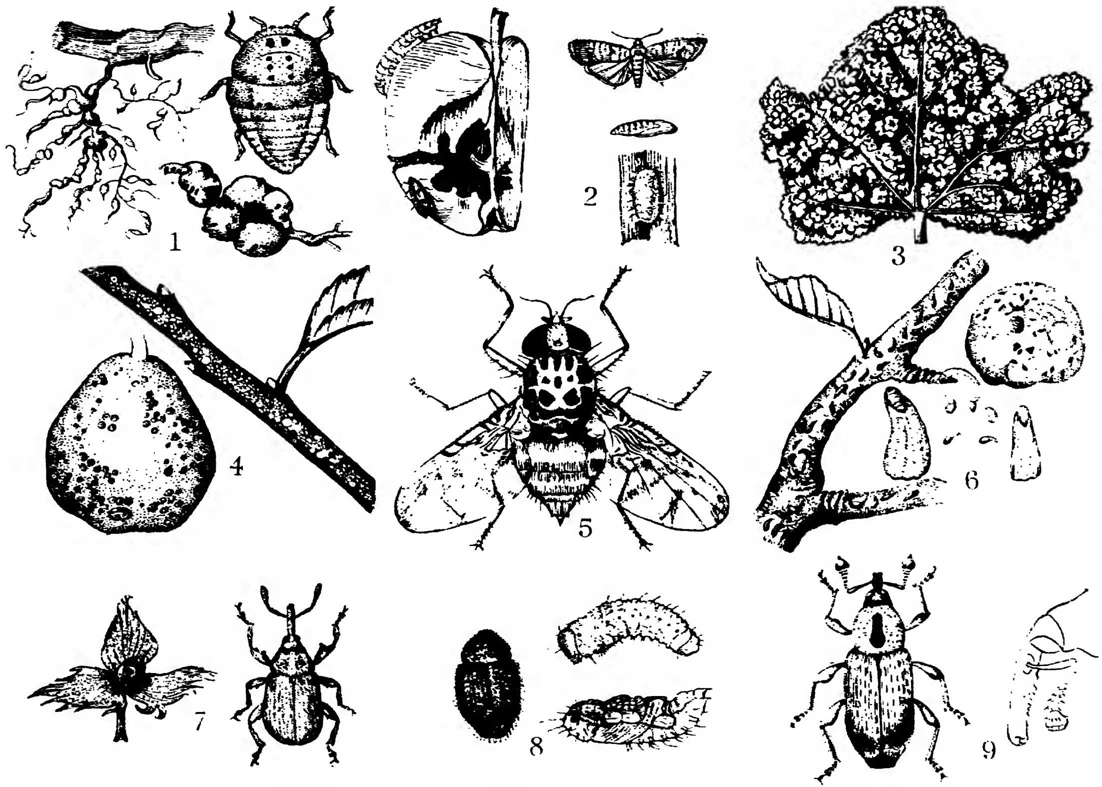
chances of gaining admission into the country, and which have therefore to be carefully watched. In this paper I have attempted to enumerate briefly some of the more important insects of foreign countries which are likely to be introduced into India in some way or other unless proper precautions are adopted to prevent the same.

The geographical position of India might, on the whole, be said to be not so favourable for the introduction of foreign pests as that of most other countries. For, India is more or less isolated, and the countries adjacent to it on the north could hardly be classed as regular agricultural tracts. Besides, there is the mountain wall on the north-west, north, and north-east, and all round below is the sea. This safe position perhaps accounts to a considerable degree for the absence of introduced insect pests. Though a more or less immune condition has been maintained till now, it is very doubtful whether such a safe state of affairs could possibly be kept up in future unless proper measures are adopted. For, in these days of quick and easy transport facilities for all sorts of agricultural products, both by land and sea, there is every likelihood of foreign pests entering the country without our knowledge. The steamships that travel all over the world form the best media of transport in this matter.

At present the countries from which we are likely to get undesirable insects introduced are Ceylon, Java, Philippines, China, Japan, Australia, and New Zealand in the east and south; and now that the Panama canal is open, there is even a chance of South America and West Indies contributing in this direction. On the west we have Africa and the Mediterranean countries of Europe and West Asia. It may, however, be argued—and it is perhaps true to some extent—that insects from temperate regions may not be able to thrive in the tropical climate of India. But this cannot be the case with all insects, as some are able to adapt themselves remarkably to their new homes; nor is it safe to try any experiments in this matter. The well-known saying "Prevention is better than cure" is as much true in this respect as in other affairs. Let us see how and by what means insects are likely to

travel and get entry into new regions. Many agricultural products when carried from one country to the other for trade or other purposes, are likely to carry with or in them some of the insect pests of the country of origin unless noticed by the exporter and destroyed in time. In many cases the insects are very minute or contained inside agricultural products and thus escape easy detection. And when once they gain entry into some port of a country they have very good chances of finding their way into the interior.

The commonest and most important of agricultural products in which insects thus travel are chiefly fresh vegetable products, such as bulbs, orchids, sugarcane, sweet potatoes, yams, fruits, seeds, cuttings of ornamental and other plants, moss, peat, tubers and nursery stock of all kinds. Bulbs, orchids, and valuable hot house and ornamental plants are often brought by travellers from one country to another as curiosities without in the least suspecting that they are in many cases bringing in undesirable insect pests with their valuable luggage. It is true that orchids or ornamental plants and their insect pests are not going to affect the agriculture of the country because these are not of any direct economic importance. But what might happen in some cases is that some of the insects on these introduced plants might change their food-plant in the country of adoption, and if this new food-plant happens to be an important field crop, the danger to agriculture becomes quite evident, and this important contingency has always to be borne in mind. Vegetables, roots, tubers and fruits not only travel as cargo, but as necessities for people on board ships. So far as I know, fruits of various kinds, such as apples, oranges, pears, grapes, etc., and nursery stock of these fruit plants are received into India from different Australian ports. Similarly, nursery stock of fruit trees, etc., are also received from Europe chiefly by some of the hill plantations. Sugarcane of new varieties is sometimes got down by Government and private concerns for seed purposes from the West Indies, Java, Mauritius, Hawaii, etc. It is also found that seedsmen and nursery gardeners in the important cities get a good many seeds, bulbs, etc., from other countries, often even by post. These are some of the known media by which we are able to trace the



(1 & 3) Grape-vine Phylloxera; 1 shows root form and 3 the leaf nodules (After Marlatt);
(2) The Codlin Moth-damaged apple and different stages of the moth (*From U. S A. Bulletin*);
(4) The San Jose Scale on pear (After French);
(5) The Mediterranean Fruit Fly, magnified (from *Insect Life*);
(6) The Oyster Shell Scale on apple (After French);
(7) The Cotton Boll Weevil—grub in boll and weevil (×3);
(8) The small Sweet Potato Weevil of Hawaii—beetle, grub and pupa, ×6 (After Fullaway);
(9) The West Indian Sugarcane Beetle, ×2. (From *Insect Life*).

entry of different exotic pests into the country. In addition to these, it is possible that insects may be carried in other things which one would least suspect—some examples of these are packing materials, bird or cattle food, bird plumage, hunters' trophies, etc. Thus the chances of foreign insects getting admission into the country are easy and many, and hence the need for a more careful and strict quarantine at places of entry.

So far as the existing insect pests of India are concerned, we have not sufficient records to show which are introduced ones and which are foreign; but we might name two or three which might be classed as introduced ones, having become naturalized and very well recognized as pretty bad pests. The potato tuber moth (*Phthorimaea operculella*), the diamond-back moth of cabbage and cauliflower (*Plutella maculipennis*), and the green bug of coffee (*Lecanium viride*) may be given as examples of such. We have no accurate records as to when and how these gained entry into the country, and it is now too late and impossible to drive out these insects which have already acclimatized themselves to their adopted home.

We will now consider some of the important insects which are bad pests in other countries, and which are likely to get entry into India unless both the Government and the importers of agricultural products are on the alert and keep out such undesirable insects. It is therefore thought that information on some of the important foreign insects might be of some help at this moment when the Pests Act is just coming into operation.

LEPIDOPTERA (Moths and Butterflies).

In this group of insects the young one or the caterpillar stands a good chance of travelling inside vegetable tissue.

The Codlin Moth (*Carpocapsa pomonella*).

(Plate XIV, fig. 2.)

The most important and the best known of these insects is the "codlin moth" (*Carpocapsa pomonella*). It is the most

destructive of apple insects. The caterpillar bores into the fruit. The adult is a beautiful moth with a wing expanse of ¾ inch. The annual loss to the United States caused by this insect was estimated at 16,000,000 dollars in 1909. It is said to be a native of the Mediterranean countries, and is found in England, America, and Australia. There is a record of this insect from Ladak in Kashmir in the *Ann. M. N. H.* of 1900. But it is probable the identification was a mistaken one. It might be the "oriental peach moth" referred to below. However, it is needless to state how important it is to keep out this pest from India.

The Orange Tortrix. (*Tortrix citrana*, Fern.)

Though not as serious as the codlin moth, this small insect is a bad pest of oranges in California and adjacent countries, and stands a very good chance of travelling in orange fruits.

The Peach Twig Borer. (*Anarsia lineatalla*, Zell.)

This insect is one which is likely to be carried in nursery stock of stone fruits. It is said to be a native of West Asia and is now found all over Europe and America. If this insect is already present in India, it must be found in the northern fruit tracts. The peculiar habit which this insect has of hibernating in nursery stock helps it in getting widely distributed.

The Oriental Peach Moth. (*Laspeyresia molesta*, Busck.)

This is different from the peach twig borer and affects both twigs and fruits. It is a native of Japan and has been introduced into the United States of America. The adult moth resembles the codlin moth to some extent, but there are striking structural differences. The full-grown larva is smaller than that of the codlin moth. It might also be mistaken for the peach twig borer, but the differences are clear on closer examination. The insect can get itself distributed as larva inside fruit, or as cocoons on the outside of the plant. Nursery stock may also carry hibernating larvæ.

COLEOPTERA (Beetles).

The insects of this group, which are likely to be introduced, are all beetles belonging almost wholly to the group of weevils, the grubs of which are fleshy and footless and bore into vegetable tissue.

THE COTTON BOLL WEEVIL. (*Anthonomus grandis*, Boh.)

(Plate XIV, fig. 7.)

The most important of exotic beetle pests is the Mexican cotton boll weevil of Texas and adjacent States in the United States. The annual loss to cotton growers from this insect is considerable. The grub bores into the boll and enters the seed. The beetle is $\frac{1}{5}''$ in length and has a uniform greyish colour with a prominent snout. The pest may be easily carried in seed and in shipments of unginned cotton from one country to another. The loss caused by this insect is estimated by Townsend at £ 1,600,000 annually to the United States of America.

THE WEST INDIAN SUGARCANE BEETLE. (*Sphenophorus obscurus.*)

(Plate XIV, fig. 9.)

The fleshy grub of this weevil bores into the tissue of sugarcane. Seed canes containing the grub can easily spread the pest into new tracts. The grub is pale white in colour and footless. The adult insect is about $\frac{3}{4}''$ long and has a dark reddish-brown colour.

THE SMALL SWEET POTATO WEEVIL OF HAWAII. (*Cryptorhynchus batatæ*, Water.)

(Plate XIV, fig. 8.)

This is a small insect similar to the mango seed weevil of India. It is a pretty bad pest in Hawaii and a strict quarantine is imposed on imports of sweet potatoes into California and other American States. The small pale white grubs bore into the tubers. The insect should not be confused with the common sweet potato weevil (*Cylasformicarius*) which is blue and red and resembles an ant in form.

The Plum Curculio of the United States of America (*Conotrachelus nenufer*, Herb.) is another important fruit pest of America which might be added to the list of undesirables. The apple blossom weevil (*Anthonomus pomorum*) of Europe has travelled from Europe to America and it is not unlikely that it might come to India also.

DIPTERA (Flies).

Among flies, fruit flies form the chief insects which generally spread from country to country in different kinds of fruits.

THE MEDITERRANEAN FRUIT FLY. (*Ceratitis capitata.*)

(Plate XIV, fig. 5.)

The most dreaded of fruit pests for which a strict watch has to be kept in India is the notorious Mediterranean fruit fly. It is one of the most serious pests which the orchardists have to fight against. Fortunately it is at present absent in India, though the chances for its entry are great and many. It is found in Europe, South Africa, Australia, New Zealand, and California. It was first noted on oranges from Azores, but now it is found on almost every fruit. The white pointed maggots riddle the fruit pulp and cause considerable damage. We have our native fruit fly (*Dacus cucurbitæ*) which is bad enough on melons of all kinds and on other cucurbits and mangoes, and it will be a very serious matter if the Mediterranean fly gets entry. The travelling public who make pleasure trips might carry fruits to their friends, or for their use, and thus distribute the pest unconsciously.

THE QUEENSLAND FRUIT FLY. (*Dacus tryoni.*)

(Plate XV, fig. 2.)

This is another fly attacking fruits in West Australia and doing appreciable damage. This insect has also chances of getting introduced. In habits it is exactly like ordinary fruit flies.

PLATE XV.

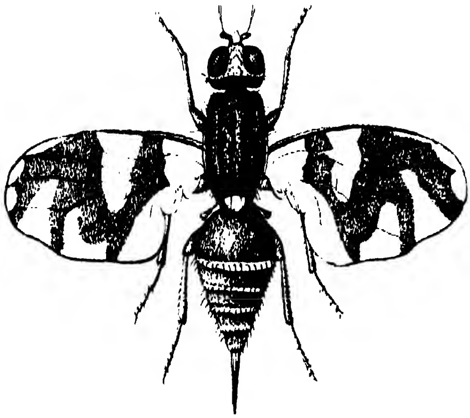


Fig. 1. Apple Maggot Fly of America, magnified.
(After Slingerland.)

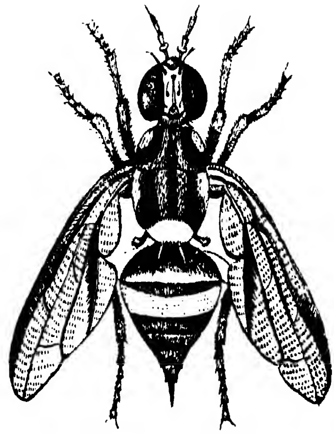


Fig 2. Queensland Fruit Fly, magnified.
(After Froggatt.)

3. The Japanese Fruit Scale. (*From Fortici Bulletin.*

THE APPLE MAGGOT FLY. (*Rhagoletis pomonella.*)

(Plate XV, fig. 1.)

This bad pest of apple in the United States of America is also an important exotic fly pest likely to be introduced.

Another notorious fruit fly is the olive fruit fly of Italy (*Dacus oleæ*).

The most important of all these fly pests is, of course, the Mediterranean fruit fly. The best method is to destroy all maggoty fruits received from foreign sources. This will not only prevent the above-known ones, but would check some species which are not so well known, but which might prove serious.

BUGS.

SCALE INSECTS, MEALY BUGS, AND PLANT LICE.

It would be difficult to point to any group of insects whose ravages have been more seriously increased by human interference than the insects mentioned above, especially scale insects and mealy bugs. Of all insects these are easily carried from country to country and some of them adapt themselves remarkably to their new homes. Most of them are minute in size and will stand long journeys; their powers of multiplication are also remarkable. During the course of my studies regarding these insects within the past two or three years, I have observed several scale insects which appear to be introduced. One can very well form an idea of the possibilities of distribution of these insects, when it is known that over thirty species of scale insects have been noted on orchids alone. The following are some of the most important foreign insects of this group.

THE SAN JOSE SCALE. (*Aspidiotus perniciosus.*)

(Plate XIV, fig. 4.)

The first rank amongst scales must be given to the San Jose scale.[1] This may be considered as the foremost of fruit pests in most

[1] *The Agric. Journ. of India*, vol. XII, pt. IV, p. 525.

countries. It is believed to be a native of China; it is now found in South America, United States, Japan, Australia, Hawaii, etc., etc. It has been found attacking pear, apricot, apple, plum, quince, nectarines, etc.; it attacks all parts of the plant—leaves, fruit, trunk, stem, etc. The scales are small and oval and often found in thousands on the surface of fruits.

THE OYSTER SHELL SCALE. (*Mytilaspis pomorum*, Riley.)

(Plate XIV, fig. 6.)

Unlike the San Jose scale, this insect has a more or less mussel-shaped, narrow and elongate scale, rounded at one end and tapering towards the other; it is pale brown in colour. It is found as a pest of fruit in America, Australia, New Zealand, Egypt, Algeria, Canada, South America, and Japan. Just like the San Jose scale it attacks fruits of different kinds and gets distributed in fruits and nursery stock. It is one of the very destructive scale insects of the world and has been noted on fruits of various kinds.

THE PURPLE SCALE. (*Mytilaspis citricola*, Pack.)

In general appearance this scale resembles the oyster shell scale, but is darker in colour and more curved than that species. It generally attacks fruits and foliage of all kinds of *Citrus* plants. It has a very wide distribution, being found in Ceylon, Australia, Africa, Europe, and America. This insect is equally liable to be brought into India with oranges, etc., from these countries.

THE COTTONY CUSHION SCALE. (*Icerya purchasi.*)

(Plate XVI, fig. 1.)

This is a well-known and destructive scale insect; in general form it is different from the San Jose, the oyster shell or the purple scale. The body covering in this case is not a hard scale, but a soft cushion made up of white cottony matter, and the cushion arranged in a characteristic manner. The native home of this

PLATE XVI.

Fig. 1. *Icerya purchasi* clustered orange twig, about natural size. (From Essig's *Injurious and Beneficial Insects of California*, Fig. 70).

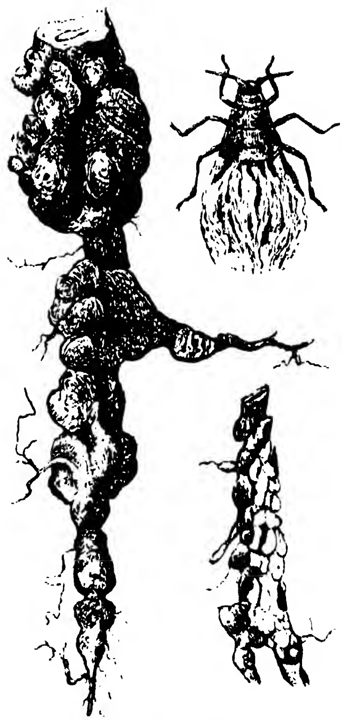


Fig. 2. The Wooly Blight, showing the characteristic nodules caused by the insect. Portion of a root with a colony of the insects (natural size), and a single insect magnified. (After Marlatt.)

insect is said to be Australia, from where it has spread to Africa, Europe, North America, South Africa, and the Mediterranean region. It is very destructive, especially to orange trees, but has been noted also on a variety of other plants including grape, rose, pomegranate, *Acacia*, castor, etc. This insect has recently gained entry into Ceylon [1], and there is no knowing when we may find it in our midst.

THE LANTANA BUG. (*Orthezia insignis.*)

This mealy bug is another destructive insect which is found in most other countries including Ceylon. This has also got the cottony white laminæ. Though it is a beneficial insect when found on the weed *Lantana*, it is an undesirable creature, as it may be destructive to other valuable cultivated plants since it has been found to breed on over 30 plants in different countries. This was once found in a plantation on the Nilgiris, but was promptly destroyed.

There are several other scale insects in foreign countries which have chances of entering India any time, especially through fruit and nursery stock. The pineapple scale of Hawaii, *Diaspis bromeliæ*, Ker, is one such important insect. It is not only a pest of pineapple, but has been found on various green house plants in different countries. It is found in Europe, America, South Africa, West Indies, and Australia. Another likely pest to find its way into the country is the Japanese fruit scale (*Diaspis pentagona*) which (Plate XV, fig. 3) has already travelled to Europe. I have found the grape and pear scale (*Aspidiotus cydoniæ*), an Australian scale, on nursery stocks of grape and pear in Bangalore got from Australian nurserymen. Within recent years numerous consignments of nursery stock of fruit trees, especially navel oranges, pears, etc., have been got down from Australian nurserymen by several gardeners and private orchardists in South India, and this must have been a very good medium for the distribution of some Australian insect pests.

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[1] *The Agric. Journ. of India*, vol. XII, pt. IV, p. 525.

Grape-vine Phylloxera. (*Phylloxera vastatrix.*)

(Plate XIV, figs. 1 and 3.)

The most serious of grape-vine pests, this insect is found in colonies attacking chiefly the roots, though often found in galls on the foliage also. It is found in Europe and America. The pest is carried on rooted vines, and so becomes easily distributed with nursery stock.

The Wooly Aphis or American Blight. (*Schizoneura lanigera*, Haus.)

(Plate XVI, fig. 2.)

This pest, which is very destructive to apples, is found in almost all countries where that plant is cultivated. Its original home is stated to be Europe, from where it appears to have spread all over the world with nursery stock. As early as 1889 Atkinson described in the *Indian Museum Notes* a species of wooly aphis attacking fruit trees on the Nilgiris, and that insect appears to be the one under review; this insect has also been found off and on in the hill districts recently on fruit trees—chiefly on those imported from Europe. It is therefore a case where an insect has already gained some ground in the country. The only thing to do in this case is to prevent its rapid spreading.

Besides the above forms of bugs, species of lace wing bugs (Tingidids) and white flies (Aleurodids) of sorts are also easily transported in nursery stock from one country to another.

Of over twenty insects noted above, the most important ones to be guarded against are the *Codlin moth, the Cotton boll weevil, the Mediterranean fruit fly, the San Jose scale, the Oyster shell scale, the Cottony cushion scale, and the Phylloxera of grape-vine.*

In this paper I have only noted some of the very destructive and well known of foreign insects which have some chances of being introduced into India. It is possible that some or most of them may not be introduced at all, and even if introduced may not thrive; if so, well and good. But a warning note regarding these will not,

I think, be inopportune. It is not also unlikely that quite harmless and little known insects of other countries might, when introduced, become bad pests in their new home. Therefore, the safest course to adopt is to make arrangements at ports or places of entry to have all foreign agricultural products of a suspicious nature subjected to a thorough examination, and to destroy or fumigate all insect-infested materials before they are allowed to enter the country.

We, in India, have any number of indigenous insect pests that give us much trouble and bring about considerable loss to the country. We would therefore be multiplying our troubles if we allow alien insects to gain entry into the country. The object of this paper will be very much gained if at least educated cultivators, and those having dealings with foreign countries in agricultural products, realize the danger of allowing foreign pests into the country and do their best to prevent it. If they find it impossible to act effectively in the matter by themselves, they would do well to bring the matter to the notice of the authorities promptly.

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Revenue and Agriculture Department,
1914-15.

Photo by Fred Bremner,
Simla and Lahore.

Original Articles.

QUO VADIS ?

THE PROBLEM OF THE CO-OPERATIVE MOVEMENT IN INDIA.

BY

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"THE frail barque of Co-operation in India"—to borrow the language of the late Sir Harvey Adamson—, was launched and blessed by Government in 1904. Where the little ship would get to nobody quite knew; and there was the usual chorus of birds of ill omen to grate the public ear with a melancholy song. Some said that a co-operative movement was impossible in an Indian environment; others scented danger in the air, thinking that co-operation and socialism were but two names for a single evil. However, the ship set sail, albeit there was no favouring gale of enlightened public opinion behind it. This, of course, was not to be wondered at. The proceedings of the Sixth International Co-operative Congress, held at Budapest in 1904, contain two papers only on Indian co-operation. The one paper is by Mr. Ambika Charan Ukil, "General Secretary of the Co-operative Union of India." "Our Union," reported the General Secretary,—and we may pause to ask what has become of it ?—" Our Union has made efforts to collect materials for a statistical account of the progress of co-operation in India. The result is, however, disappointing. In answer to a considerable number of question-sheets sent out to co-operative societies of whom we had heard, we have received only an insignificant number of replies; and those replies give no information except that, in

the opinion of the writers, the proportions of their business are still too small to merit mention." The other paper is by Mr. H. E. L. Dupernex, I.C.S., and in it we read that the co-operative movement had made a start and "had been lifted out of the region of academic discussion." This, then, was the manner of the launching of the co-operative movement in India. Government passed an Act, appointed Registrars, and addressed Provincial Governments in a despatch which, compressed into tabloid form, amounted to a command to "get a move on!" Such a procedure recalls to a mind not altogether irreverent the first chapter of the first Book of Moses. But with this great difference. When the co-operative movement in India was made to order there was no great architect responsible for its design. Mr. H. W. Wolff was for a time the wise and kindly *deus ex machina* to whom the Government made occasional references. And Mr. Wolff has never worked in India. It was, in fact, left to the provincial Registrars to *dree their ain weird*; and so it came about that each province, in the course of a few years, possessed its own particular brand of co-operative bricks in the shape of village credit societies of different types.

In 1910, I wrote :—"The great difficulty in co-operative organization is that precedent cannot always solve our problems for us. Co-operative credit must, of course, embrace certain broad principles. But the capable organizer will resemble the skilled *chef*: there may be a sameness about the ingredients ; yet the recipes will be different and the results all excellent. Nevertheless, however cunning the artist, however exquisite the art, no *chef* can hope to succeed unless he knows the tastes of the man he has to please. And so with co-operative credit. The particular blend must suit the circumstances of the people and the locality. It is *in the blending* that success or failure is included. Not even a Raiffeisen can hope to organize successful co-operative credit societies without a sound knowledge of the wants (and the limitations) of the locality he is working in. The blind cannot lead the blind ; so before the organizer commences operations he must study the conditions and the environment of the village he has to handle. He must become acquainted with the trade, the rates of interest, the customs, the agriculture, and, above

all, the men of the neighbourhood." Every other Registrar was saying, writing, and thinking much the same sort of thing at about that time. Co-operation, blessed word, was the new medicine for all ills. It was thought that it could be administered in packets tied up with red tape, to be obtained from Registrars whenever needed. Once, when a town had been destroyed by fire, a Registrar was sent for and told to form the homeless inhabitants into co-operative societies and to see that they got money to make a new town with. The cry was all for rules. "We don't want to be bothered about the principles. Give us the rules and we will do the rest!" That, put generally, was the attitude of the provincial and district executives. As for the great non-official world the cry there was all for State aid, for money and for ministerial staff. It was not, however, a niggardly policy which shut the public purse, but acceptance of Mr. Wolff's warning that patronage would spoil that co-operation on the purity of which the success of the entire movement must depend.

Now it is obvious that a "co-operative credit society" which cannot find money for its members is unworthy of the name. Where then was the money to come from? "You will get local deposits," said Mr. Wolff comfortably. But the Indian peasant, like his brother in other countries, is poor, secretive, and suspicious. The nature of his work tends to make him an individualist to the very marrow, with less disposition than any class to work for the common welfare while working for his own. Varying with the seasons, his hours of labour are often prolonged from sunrise till gloaming and even far into the night. He is continually haunted by fears for his crops. And in his household the meals taken in common with his family, the common pursuit, the self-contained home, the blood-bond of kinship, are salient factors which must be taken into account when introducing co-operation in any form to him and his class. The struggling cultivator is actuated little by sentiment; and, if he co-operates, it is solely because he hopes to obtain individual benefit. In introducing co-operation to him, one has to contend not only with the sluggishness of ignorance and the apathy of despair, but with the suspicion of being actuated by a desire to

overreach which does not appear on the surface. The Indian peasant who had no money wanted to join a credit society in order to obtain a loan at a rate of interest below that at which the rural moneylender was willing to accommodate him; his richer brother had no use for co-operation; and the village usurer saw ruin and showed fight.

"Needs must when the devil drives." Funds for the credit societies had to be got; and so Registrars, feeling their way cautiously, had recourse to the formation of district or central co-operative banks. I use the word "recourse" because, in truth, there was very little that was co-operative about the first Indian central banks. It was necessary to explain to local capitalists the meaning of co-operative credit, and to show that the societies afforded scope for safe investment with a prospect of a good return. The banks were to make a profit for their shareholders; and the shareholders subscribed *for profit.* "In order to love mankind," said Helvetius, "one must not expect too much from them." Of course, there was a good deal of adverse criticism. In the first place, it was urged that banks of this kind were not the "societies" which the Government of India contemplated when undertaking legislation. Secondly, it was pointed out that they were mere profit-making machines. It was stated that the object of co-operative credit was to obtain reasonable credit from reasonable creditors. Meanwhile, the Government of India, with deep wisdom, stood by and watched, —and waited. The fact was that precedent could *not* solve the problems of the Indian co-operative movement in its early stages. Before passing the Co-operative Credit Societies Act of 1904, Lord Curzon appointed a small committee, under the presidency of Sir Edward Law; and the deliberations of that committee may be said to have begun and ended with the primary unit of co-operative organization, namely, the village credit society. The Act of 1904 contained no formal recognition of central societies formed of other societies, nor did it expressly cover any form of co-operation other than co-operative credit. To remedy these and other defects which experience had brought to light, a new Act was passed in 1912 which dealt with co-operation of all kinds.

Between the years 1904 and 1912 the movement in India had made much progress. The district or central co-operative bank, admitting village credit societies to membership, had proved its utility. Indeed, without this type of institution the village credit societies would have got no money, and, as Mr. Wolff has expressed it, "what you want in your banks at the outset is, not members', but *other people's* money." Once the position of central banks had been brought within the four corners of the new Act, the co-operative movement made a great stride forward.

In 1915 there were in India 17,327 societies with 824,000 members and a working capital of almost nine crores of rupees. By that time it had been discovered that the central district banks did not carry heavy enough guns. They could not command credit outside the limited field of their operations. Moreover, feeder banks of the district type are subject, only in a less degree than the individual societies they serve, to vicissitudes of season and fluctuations in the demand for money; and, in their turn, they require further agencies from which they can obtain money in the busy months and through which they can utilize it in the slack season. Some central banks, thanks to the good offices of Registrars, had obtained loans or cash credits from large joint stock banks. But it goes without saying that a co-operative *movement* cannot stand still; movement there must be, either forwards or backwards; and the joint stock banks found the district co-operative banks difficult to deal with. Difficult, that is, not in the sense that they were slack or dishonest, but inconvenient as customers or clients, and this for two reasons. In the first place, the joint stock bank is, as a rule, remote both in methods and in locale from the district co-operative bank. And, secondly, the requirements of credit societies are most difficult to estimate in advance because they depend, in great measure, on good or bad harvests. Thus, a district central bank may be clamouring for financial assistance one moment and, the next, wondering what to do with surplus funds.

It was at this juncture that provincial central banks appeared on the scene as links between joint stock or presidency banks and the district co-operative banks. The advent of the provincial

central bank saved weak district banks from perishing for want of funds, and greatly benefited strong district banks, because it provided a convenient clearing house through which surplus deposit or other money could be distributed and retained within the circle of the provincial movement. But it did little or nothing to help Registrars towards a satisfactory solution of the problems of supervision and audit, problems which in India are extraordinarily difficult because of the intense degree of illiteracy in the villages. It is more than doubtful whether European critics of Indian co-operation grasp the nature of a Registrar's work. Writing in 1910, at a time when there were only 3,498 societies in the whole country, Mr. Wolff pronounced that "the time had indeed come when the movement must, from a quasi-official, be expanded into a national movement, if it is to be carried any further." But illiteracy makes any such expansion difficult if not impossible. As Mr. Montagu and Lord Chelmsford have pointed out British India has two and a half times the population of the United States, and 226 out of 244 millions of people lead a rural life. Agriculture is the one great occupation, and only 6 per cent. are able to read and write. "What concerns the Indian peasant mainly" the words are those of Lord Chelmsford and Mr. Montagu, "is the rainfall or the irrigation supply from wells or canals, the price of grain and cloth, the payment of rent to the landlord or revenue to the State, the repayment of advances to the village banker, the observance of religious festivals, the education of their sons, the marriage of their daughters, their health and that of their cattle. They visit the local town on bazaar days and the sub-divisional or business centre rarely on business or litigation. They are not concerned with district boards or municipal boards; many of them know of no executive power above the district officer, and of Parliament or even of the legislative councils they have never heard. In one province it is stated that 93 per cent. of the people live and die in the place where they were born." It may be doubted whether this picture, striking as it is, brings out the apathy exhibited by the Indian villager towards education and sanitation. It certainly does not bring out the fact that "local towns" are few and far between. For, a town being defined as

"a continuous collection of houses permanently inhabited by not less than 5,000 persons," there are only 117 towns in the whole of an Indian province which is as large as England, Scotland, and Wales put together. In the same province the average population of 42,000 villages is 311 persons only! India is, in fact, a country not of towns but of villages, and, moreover, one in which many new roads, railways, and village schools are very badly wanted if there is to be any comprehensive scheme of rural development.

It has been stated by the Government of India that 3 millions of the people are directly affected and benefited by the co-operative movement; and we may readily agree that "the movement in India is only at its beginning," and that "the progress made in the first stage has been unequalled in any other country." Such agreement, however, ought not to blind us to the fact that there is only one co-operative society in India for every 20,000 of the population engaged in agriculture; and, bearing in mind that Indian villages are, after all, very small places, it may be estimated that there is room for at least 40 credit societies for every 20,000 cultivators,—provided always that the societies can be audited, educated in their work, and financed, and that the margins of economy which they effect for their members (and for future generations of members) are not whittled away by a defective co-operative cycle and an ill-balanced banking system.

The purpose of the co-operative movement is not only to democratize credit but to democratize production as well. Sir Horace Plunkett has more than once declared that if he had his organizing work in Ireland to do over again, it is with banks he would begin, because they are found to pave the way to other forms of co-operation. They supply the means as well as the training. Co-operative banks are, in fact, the great driving wheel of the whole movement. But, at the same time, they form part only of that great engine of co-operation which has contributed so enormously to the progress of modern countries. It is, of course, most important that, at every turn, the savings effected by co-operative economies should be used in such a way as to benefit the individuals from whose joint action they have sprung; in other words,

there must be a full cycle of co-operative activity to secure to the producer the full benefits of co-operation. In the absence of such a cycle,—and in 1917, out of 23,000 societies, there were in the whole of India only 1,558 societies for purposes other than agricultural co-operative credit,—much of the energy put into the movement runs to waste; which means that the movement towards better business is retarded and, in many cases, prevented, and that the subsequent stages of better farming or working and better living can never be reached at all. As matters stand at present there is little or no scope for the profitable employment of the reserve funds and surplus deposits held by the movement, while considerations of banking prudence compel the retention, at a loss, of large sums of money in a fluid or liquid state. Frequent tinkering with the rates of interest offered by co-operative banks and societies to depositors has an injurious effect upon public opinion and interferes with the flow of deposit money; and, because the co-operative cycle is incomplete, there is at present no means of passing on the surplus capital of agriculture to fructify, under proper guarantees, in industrial co-operative enterprise. Nor, as yet, is there (*a*) any organization of mortgage credit by means of the bonds which have, in other countries, become an established feature on the stock exchanges, and which, because they find a ready market, are a very suitable and convenient form of banking security, or (*b*) any regular facility for the discount of the promissory notes of societies. These grave defects in the scheme of Indian co-operation must be remedied if the movement is to take its proper place as a powerful factor in the economy of the country.

But difficulties of the above kind are not all that the co-operative movement in India has to contend with. The problems of audit and supervision are also acute. If the number of societies increases, then a Registrar is hard put to it to provide audit and supervision; if the number of societies is not allowed to increase, then, unless the flow of deposits be stopped, the movement has to carry surplus funds at a loss. There are obstacles, also, in the way of any practical application of co-operative principles to purposes other than credit. It is, for instance, very often most difficult to get field produce to

market in India because of the prevailing absence of roads. In a certain tract of wheat country, which is about as large as an average English county, the course of trade is as follows. Messrs. — — conduct their purchases through a local agent; the local agent works through sub-agents, the sub-agents work through *banias* or *mahajans*; and the *mahajans*, again, through petty middlemen, each one of whom has a regular beat or group of villages which he plies. These middlemen, or *baiparis* as they are called, conduct their operations with pack-bullocks or ponies. They sell cloth and groceries to their cultivator clients and take payment, when the time comes, in grain or other produce. The *baipari* is the agent; his principal is the *bania* or *mahajan*. And once a cultivator is in the *bania's* books he seldom succeeds in getting out of them. It requires a *comprehensive* organization to break down a system of this sort,—a system to which the cultivator himself is thoroughly accustomed and which he finds it difficult to see beyond. It is, in fact, impossible for the co-operative organizer to take the cultivator beyond and out of reach of bad economy, until considerable changes have been effected in Indian rural environment by the multiplication of roads, of wheeled vehicles, of farms for the production of pure seed and for the demonstration of improved methods, of facilities for co-operative distribution, supply, storage, and sale, —of all these things, and, above all, of schools, so that, in due course, what is now, perforce, a system of audit and control centralized in the hands of a few officials and non-officials belonging to the educated classes may, in the hands of the people themselves, become natural, spontaneous, and decentralized. A great deal of water will have to flow under Indian bridges before that happens; and it never can happen until the problems of rural development are dealt with scientifically and systematically, each as part of a co-ordinated whole, and not by a purely departmental watertight compartmental system. Co-ordinated effort, systematic thinking, a plan of campaign,—these are three essentials to any scheme of rural reform, and it matters not a pin to India whether they are provided by Boards of Development, by Development Commissioners, or by Rural Organization Societies, so long only as they are provided. Substantial as the

structure of the co-operative movement in India undoubtedly is, the time has come to take stock of the situation. There is a period of development and reconstruction before the British Empire, and an industrial vision is before this great country, a vision which can never come to anything until the co-operative movement with its "better business, better farming, and better living" uplifts the villages of India.

The reader, if he has survived the discourse, will probably be thinking that this sort of thing is all very well but without point unless accompanied by useful suggestion. "Mistiness," wrote Cardinal Newman, "is the Mother of Wisdom"; and it is easier to point out present imperfections than to devise future remedies. Nor is it often possible in India, a suitable field for prudent experiment if ever there was one, to state. in advance, that this economic measure or that is certain to succeed. Every Indian reformer ought to know of the famous city which had three gates. On the first the horseman read inscribed, "Be bold"; and on the second gate yet again "Be bold, and evermore be bold;" and on the third it was written, "Be not too bold." But though prudence is a virtue in co-operative workers excessive caution and lack of foresight are not; and if discussion does no more than promote intelligent thought it is not without benefit.

In conclusion, therefore, and for a brief space only, I would invite attention to the achievements of Japan in the field of agricultural and industrial co-operation, for it is a field in which she has earned universal praise and approval. An Italian observer, for instance, declares that the work of the Japanese in this direction "must be regarded as one of the most brilliant manifestations of clear sighted and orderly human activity."

It should be remembered that before Japan entered upon her present era of industrial development she had to meet exactly the same problem as that which now faces the agricultural and industrial pioneer in many parts of India. Japan had not enough labour; so she set to work to increase the population and, with the prospect of rising prices before her, the produce of the fields. In both these undertakings she has succeeded. Within a period of about

50 years her population has doubled, while the amount of rice produced per head of population is greater than before. In the matter of her food supply—we may exclude from consideration the temporary shortage caused by abnormal industrial activity during the war—Japan is short by only 5·6 per cent. of being self-supporting. Again, Japan is a country of small holdings, with a co-operative system based upon that fact. Seventy per cent. of Japanese farmers possess land of an area less than 1 *cho* (1 *cho* = $2\frac{1}{2}$ acres), while only 3 per cent. possess land of an area of more than 3 *chos*. For this reason, although cultivation is intensive and the requirements of the rural Japanese are small, secondary agricultural industries, such as paper-making, are of great importance. It is generally held in Japan that the yield of these industries varies between 10 and 25 per cent. of that from agriculture pure and simple. Rural progress in Japan has been scientifically guided and has followed a symmetrical plan of campaign. Till recently the Japanese administrative unit was the village or, as we call it in India, the *mouza*. This unit, cramped and narrow, has been replaced by *aza* groups, containing as many as 19 villages. These local associations have their own measure of self-government under a council of village elders and enjoy considerable powers of taxation to meet expenditure upon works of local improvement. They are the points at which the agricultural, educational, co-operative, irrigation, and engineering experts of Government impinge upon village life; and there is no doubt that the sense of association and responsibility thus fostered has given a powerful impetus to the development of Japanese resources. It has been found that the enlargement of the parish and the creation of a new responsibility make an antidote to the stagnation produced by individualism, prejudice, and narrowness of ideas,—in short, by the peasant spirit. Every village group has three or four primary schools, its own agricultural association, council chamber, and circulating library; and 80 per cent. of Japanese villages have co-operative societies, more than half of which are for credit and are worked on the principles of unlimited liability.

The Japanese have been quick to grasp that any country which desires to make co-operation the means of its advancement

must, sooner or later, meet with disappointment if it follows the plan of trying to fit square pegs into round holes. Some twenty years ago the cultivated land of Japan was, for the most part, subdivided into small, narrow, and irregular lots, often imperfectly or not suitably irrigated and drained, with an insufficient and generally unreasonable system of roads. In order to increase the produce of the soil by means of irrigation and drainage and appropriate changes in the kind of cultivation, to diminish the areas left unproductive as boundary land between two contiguous holdings, and to obviate all the inconveniences caused by the existence of numerous small lots belonging to the same proprietor but scattered over a large area, the Government of Japan passed a law for the readjustment of farm lands. This came into operation in 1900, and was amended in 1909 when it was taken up for consideration with the law governing the working of co-operative societies, upon which it has an important bearing. The latter law is good and comprehensive. It deals with a system which includes a Central Association of Co-operative Societies for the whole of Japan, federations of co-operative societies in the various provinces of the Empire, a Land Mortgage Bank for all Japan, 46 provincial agricultural and industrial banks, and primary co-operative societies of all kinds. The organization is democratic and representative of all interests involved, and, even in a land of small holdings, it includes such institutions as the *beiken-soko*, or co-operative warehouses for *graded and selected rice*. The cultivator deposits his rice—which must be up to standard—and, in exchange, obtains a deposit warrant which he can discount at his co-operative bank. In 1910 the Japanese Government commenced to make use of postal savings which are entrusted to the Deposit Sections of the Department of Finance, circulating them in the shape of loans to the *Noko Ginko* (Provincial Agricultural and Industrial Banks financing co-operative societies) and to the *Nippon Kangyo Ginko* (The Land Mortgage Bank of Japan). The Land Mortgage Bank guarantees the bond issues of the Agricultural and Industrial Banks, and helps them to keep their resources fluid by discounting their paper.

It is, indeed, the opinion of competent critics that despite the poor reputation earned by Japan in matters of commercial morality, there is a definite endeavour afoot in that country to have in the rural districts better men, women, and children. The highest aim of rural progress is to develop the minds and hearts of the rural population, and in all discussion of the rural problem it is necessary not to lose in technology a clear view of the final object. This essential aspect of the co-operative movement has not been overlooked by Japanese statesmen.

AGRICULTURAL HOLDINGS IN THE UNITED PROVINCES.

BY

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THE character of tenants' holdings in the United Provinces and the possibility of effecting some rearrangement in them with a view to facilitating the development of agriculture have recently been attracting some attention. The discussions on the subject generally proceed on the assumption that these holdings are, in the main, so far uneconomic in size and incompact as to preclude the adoption of many forms of agricultural improvement. But the information on the first of these points is very inadequate, and all conversant with the land records system of the provinces will appreciate the difficulty of arriving at any definite idea as to the size of the average holding. This was strikingly illustrated by the divergence of opinion expressed by witnesses appearing before the Indian Cotton Committee when questioned as to the size of a holding in the cotton-growing tracts. As a basis for discussion, therefore, regarding the desirability or otherwise of any rearrangement, it seems essential to obtain clearer information both as to the size of the holdings and the extent to which they can reasonably be said to be uneconomic in character. On the second point there can be no difference of opinion; yet it would often appear that the reasons which have led to formation of incompact holdings and the difficulties, from the point of view of cultivating the land, of consolidation are not clearly understood.

An attempt has accordingly been made to ascertain the size of the average tenant's holding in different parts of the provinces

from an examination of the village registers. These are, however, primarily intended to record the nature of the tenure and the rent payable by the tenants, and the arrangement followed not only does not facilitate an enquiry of this nature, but leads to some misunderstanding of the actual position.

This will perhaps appear most clearly if, before explaining the method adopted, the difficulties of extracting the information required from the registers are set out.

1. The *mahal* * and not the village is the revenue unit, and consequently a tenant may hold land in a number of different *mahals*, the records of which are kept separately.

2. The *khatauni*† is arranged by tenures, and a tenant may hold land under several tenures. Thus an energetic family may hold land as occupancy and non-occupancy tenants and subtenants of *sir* ‡ or of other right holders, and each plot will be shown under a separate heading. Nor does the complication end here, since some of the temporarily held land may be taken on lease by a member of the group, other than the head of the family, and yet cultivated jointly.

3. In some parts of the provinces the villages are closely crowded together, and tenants hold land in more than one village.

4. The greatest complication is caused by the joint holdings. A number of persons may have rights to a particular plot ; some of whom are shown as holding other plots separately, the cultivation being also separate. As an example, 13 persons were shown as having rights in 43 acres, of whom seven were also tenants, jointly with other persons not belonging to the first group, in seven other holdings which were found on inquiry to be cultivated separately. In these cases, the original holding has usually been subdivided by a private arrangement ; such subdivisions not being recognized by the rules framed under the Land Revenue Act.

* *Mahal* is the area for which a separate agreement for the payment of land revenue is taken. It may be a single village or part of a village, or may include more than one village.

† *Khatauni* is a register of persons cultivating or otherwise occupying land.

‡ *Sir* is land held by a landholder under special privileges.

5. A striking feature in almost all village returns is the number of single fields, or small plots, held by persons not entirely dependent on their land. These comprise labourers in villages and towns, carpenters, blacksmiths, barbers, priests, etc. It is very doubtful whether these should be called "holdings" at all, and should not rather be classed as "allotments." The owners often do not own cattle themselves, but depend on their patrons or neighbours, or cultivate by hand labour. The inclusion of these plots would obviously reduce the area of the genuine holdings.

The net result of the above is often to lead to an underestimate of the size of the holding; since land held under different tenures or in different villages is not included in the calculation.

The only satisfactory method, therefore, appeared to be to take each group and ascertain from inquiry the extent of their holdings under various tenures, correcting the result and ascertaining areas from the registers. Allotments held by persons who do not depend entirely on agriculture have been excluded. This is a slow and laborious proceeding, and only a limited area in a few selected districts could be covered. But the conclusions, though very imperfect of themselves, can be supplemented by those arrived at by Settlement officers who have dealt with the question in their reports.

It is well known that the holdings in the eastern, or rice-growing portions of the provinces, are smaller than in the western, and the population is denser. On the other hand, in Bundelkhand, with an average density of only 218 per square mile, the holdings are too large for the tenants to manage with their very imperfect implements, and many include a considerable proportion of fallow or waste. The latter tract was, therefore, excluded altogether, and districts typical of other tracts selected for examination.

Gorakhpur was taken as fairly representative of the eastern rice-growing districts. Unao is a central district standing between the rice and cotton-growing tracts. Cawnpore and Mainpuri are fairly representative of the wheat and cotton-growing tracts; Meerut of the wheat and cane-growing tracts.

The results are set out below :—

District		Average holding (excluding allotments)	Area per plough
		Acres	*Acres*
Gorakhpur	...	3·19	...
Unao	...	5·00	5·5
Cawnpore	...	5·50	6 4
Mainpuri	...	4·90	5·6
Meerut	...	6·45	...

It may be mentioned that it was particularly difficult to arrive at any conclusions with regard to the Gorakhpur District, owing to the fact that large numbers of proprietors themselves cultivate land as tenants of other proprietors. For this reason no figures of the plough rate could be quoted; while those of the Meerut District are also said to be unreliable.

Taking the Settlement reports, in the Gorakhpur Settlement report it was stated that no statistics were to hand showing the actual number of occupancy tenants who were also tenants-at-will; but figures were quoted to support the assumption that, if allowance were made for land held under both tenures by the same individuals, the average would be about 3 acres.

In the Allahabad report the average was put down at 2·72 acres.

In the report of the Fatehpur District, which stands between Allahabad and Cawnpore, the Settlement officer wrote, "to obtain the average size of each holding, the total tenant area has been divided by the real number of resident holdings (non-residents being excluded). The resultant figure, *viz.*, 4·38 acres, is a small one and indicates considerable pressure on the land."

In Shahjahanpur the average tenant's holding was said to be 5 acres, and the average number of acres ploughed by every plough was found to be 7.

In Pilibhit, a somewhat sparsely populated district, the Settlement officer from inquiries in various villages estimated the average area held by tenants at 7 to 8 acres.

The matter seems to have received most attention at the Moradabad Settlement, in which district the average holding's area was put down at 6·77 acres. It is stated : "Great care has been taken in the preparation of this statement. The numbers of real tenants are those obtained after eliminating all names which have previously

occurred in the village, either in another *mahal*, or *patti*,[*] or under another section of the *khatauni*." In Agra, the average holding of an occupancy tenant plus his land as a tenant-at-will was estimated at 8·1 : that of tenants-at-will at 6 acres. The Muttra figures closely correspond. The Settlement officer of Saharanpur, who also carried out the Allahabad Settlement, writes that on the information to hand, which is by no means complete, the average holding of that district may be put down at about 8 acres.

It will be seen that there is a gradation in the size of the holdings from the west to the east of the provinces. To a certain extent this is connected with the relative density of the population, but, as the following figures will show, this cannot be the whole explanation :—

District		Population, per square mile
Meerut		648
Saharanpur		483
Moradabad		553
Mainpuri		476
Cawnpore		482
Unao ...		510
Allahabad	Eastern districts	513
Gorakhpur	Eastern districts	707
Basti	Eastern districts	654
Partabgarh	Eastern districts	624
Jaunpur	Eastern districts	746

Meerut with relatively large holdings ranks next in point of density of population to Gorakhpur ; while a number of districts have a heavier population than Allahabad where the holdings appear to be extremely small. Another explanation is afforded by the census figures showing the proportion of the population supported by agriculture alone and that supported by industries.

	Districts	Percentage of population supported by agriculture	Percentage of population supported by industries
Western	Meerut	55	21
	Saharanpur	44	22
	Agra	60	18
	Moradabad	62	18
	Cawnpore	59	14
	Mainpuri	66	14
Eastern	Allahabad	71	10
	Gorakhpur	88	4
	Basti	87	4
	Partabgarh	82	9
	Jaunpur	81	9

[*] Part of *mahal*.

Throughout the eastern districts the proportion of population engaged in agriculture alone is high, and some diversity of occupation would certainly appear to relieve the pressure on the land.

How far these holdings can be considered uneconomic must depend largely on the meaning attached to the term. It is sometimes used to imply that the holding is too minute to maintain the occupants in reasonable comfort: sometimes, that its size and situation do not admit of the application of the best methods of husbandry. But the expression must connote waste in some form; either of the land, or of human or animal power. Whatever criterion is applied, it will probably be admitted that holdings of 3 acres must be classed as uneconomic for the production of staple crops; and that they do not occupy, either fully, or to the best advantage, the human and animal labour. There is the additional disadvantage that the occupants, being barely able to get a livelihood from the land, have no surplus to devote to any form of improvement. Agriculture thus does tend to stagnate in such tracts.

The case of a 5-or-6-acre holding is open to more doubt. This is as large an area as one pair of bullocks can work properly with well irrigation, and, looking to the diversity of the crops grown, the system of double-cropping which is customary even with cotton, such a holding will keep a family of moderate size fully occupied. If enlarged to a two-or-three-plough holding, hired labour in proportion to the increase would be required. It seems somewhat idle to discuss the optimum holding of a peasant farmer, since so much must depend on a number of factors, such as the character of the soil, nature of the cultivation, facilities for obtaining water, etc. If not unduly small for present appliances, the inadequacy of a holding in the western districts might become pronounced with the introduction of improved implements.

As Japan is sometimes held up as an example to be followed in agricultural reorganization, it may be not uninteresting to compare the size of the holdings in that country. In the report of the Agricultural Bureau published by the Department of Agriculture and Commerce, Tokyo, it is stated: " It will be seen that when the arable lands in the country are distributed among each farmer's

family, the average area is 1 *cho* 7 *se* in farm lands (slightly under three acres)—the fact that our farmers live on such a small area of land may be attributable to the utilization of the farm as two crops fields." The distribution is here by family, whereas in these provinces a holding is frequently cultivated by several families, and allotments have been excluded. If the same method of calculation were followed, holdings in Japan would probably not be much smaller than the medium-sized holdings in the United Provinces.

The figures, however, quoted above do not set out the whole situation. Account has to be taken of two other factors : (1) the amount of sub-leasing which prevails ; and (2) the size of some of the groups composing the cultivating units. The extent to which sub-leasing prevails varies very much in different parts of the provinces ; being as high as 29 per cent. in the Benares Division and falling to 9 per cent. in the Meerut. Without quoting more figures, it may be said that it is most common among high caste tenants, and comparatively rare among the energetic agricultural castes, such as Jats and Kurmis. The right holder in such cases sinks into the position of a petty proprietor, leasing the whole or part of his holding to a subtenant. The latter is rack-rented and his position is precarious : his land is in consequence usually badly cultivated. The inquiry further showed that many of the cultivating units were composed of several families, sometimes as many as four and five. In some cases they cultivated in common : in others they had privately subdivided the land and, what is worse, cut up the fields. Such subdivisions not being recognized, joint liability for the rent remains, and the whole area is treated as a single holding. The figures of holdings, therefore, are so far less favourable than they appear on the surface that the area may have to maintain an excessive number of persons, and the real unit of cultivation may be something smaller than the recorded holding. These features of the land system are due to the intense pressure on the land, and, so long as the same causes remain at work, must be reckoned with in any scheme for promoting agricultural improvement by enlarging the holdings. Legal restraints have proved inadequate to prevent wholesale sub-leasing and subdivision, and these tendencies, by lowering the

real unit of cultivation, would cut at the root of any such scheme for reorganizing holdings.

Though greatly accentuated by the scramble for land and subdivision of proprietary rights, fragmentation of holdings may often be traced to the necessity of apportioning the land so that each sharer had fields for cultivation at both harvests. In a typical rice-growing tract the villages cluster on the high land which is under wheat or other spring crops, the low-lying flooded fields beyond being reserved for rice. Consolidation of holdings would bring the cultivator no nearer his land, unless the style of village architecture were so altered that he could live in the rice fields; while it would have the disadvantage that the holding, instead of consisting partly of rice and partly of wheat land, would be made up wholly of either one or the other. Owing to the irregularity of the monsoon, rice in the United Provinces is a most uncertain crop, unless irrigation is available. In those parts of the submontane districts where water is near the surface and the land generally well suited for house-building, the villages are either closely packed together or have broken up into a number of small hamlets. Here the inconvenience from incompact holdings is probably slight, and the uniform standard of the cultivation illustrates the advantages of the cultivator living near his work. It may be mentioned that the cultivators themselves most thoroughly appreciate this advantage, mainly because of the inconvenience of watching their crops when at a distance from their homes. Over, perhaps, the greater part of the provinces the difficulty of consolidation is one of water. The wells are usually in, or comparatively near, the village, the presence of a good water-supply possibly determining the site. A typical holding in such villages consists of a plot of land in the highly manured home land round the village, another in the middle zone—less highly manured, but possibly irrigable from the wells—and a third in the outlying zone which is unirrigated and given up to rains crops. Such a distribution gives the cultivator a good diversity of crops, and keeps him occupied all the year round. Distribution of the land into compact holdings would only be workable provided wells were constructed in the outer zones, and boring experience

shows this might not always be feasible. To take a man away from his water-supply to bring him nearer his work is a doubtful boon in India. At the same time there is no class of villages which would benefit more from a policy of consolidation of the holdings, if accompanied by the provision of a water-supply. The outlying zones are usually under poor and irregular cultivation, and there are often patches of waste between the villages. The establishment of hamlets—single homesteads would mean too many wells—would level up the standard of cultivation and bring fresh land under tillage. It might seem that the canal tracts offer the best opportunity for a policy of consolidation. This is possibly the case in some villages, but canal irrigation rarely extends over more than part of the villages in the United Provinces, and the same obstacle would arise, *viz.*, that some of the holdings must be entirely outside the irrigated area, to the ruin of the less fortunate in dry years. For the provinces as a whole, therefore, consolidation of holdings is, at present, a counsel of perfection ; but it could be carried out with great advantage in limited areas. When new wells are put down, or pumping plant installed to command areas hitherto either uncultivated or highly precarious, arrangements could often be made for dividing the land into plots of suitable size and letting it in compact holdings.

There would, too, be undoubted advantages in bringing together fields held by individual tenants in the same block, that is the rice or wheat-growing block, so long as the main distribution of the holdings among the different blocks were not affected. But such a measure would only be feasible if all the land were held in the same tenure and under the same proprietors.

The whole agricultural system of the provinces has in fact been adapted to meet the predominant feature of the climatic conditions, *viz.*, the uncertainty of the rainfall. This has led the agriculturist to aim at security rather than high results, and to frame his annual crop programme so as to eliminate the chances of total failure. This attitude may be seen in every phase of his operations—in the growing of two crops, often to the detriment of the main crop—in the habit of sowing mixed crops, to the despair of the statistician—in his preference for hardy, if low-yielding

varieties—and, in the land system, in the distribution of the different classes of land so as to secure at least one crop in the year. It is not conducive to good agriculture; but it has enabled a dense population to meet with success the vicissitudes of the season. A change in this attitude can only be expected with a modification of the conditions which have forced it on the agricultural population, that is, as the gradual increase of protection lessens their dependence on the annual rainfall.

THE FRAGMENTATION OF HOLDINGS AS IT AFFECTS THE INTRODUCTION OF AGRICULTURAL IMPROVEMENTS.*

BY

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In a previous paper[1] read at the Indian Science Congress in 1916, some of the more general considerations affecting the re-alignment of agricultural holdings were discussed, and it was pointed out that the present system led to very great loss of agricultural efficiency. Since that time considerable interest has been shown in the subject, and the debate at the last meeting of the Board of Agriculture at Poona,[2] based on Mr. Keatinge's paper and draft bill, helped considerably to define the issues. Mr. Keatinge's paper rendered great service in one direction amongst others, by showing that the question of the size of the economic holding, though of great importance, was not necessarily identical with the prevention of fragmentation of holdings, although the two problems had often been discussed as one in the past.

In several districts in the United Provinces, there is good reason to believe that the average holding is somewhere in the neighbourhood of three acres. It is hoped that, in the near future, further data will be available, showing the number of holdings of various sizes in villages typical of certain tracts. As to what may be considered an economic holding will depend largely on the basis one adopts, and clearly the figure chosen must vary considerably with the nature

* A paper read at the Sixth Indian Science Congress, Bombay, January, 1919.

[1] *Agricultural Journal of India,* Special Indian Science Congress Number 1916, p. 33.

[2] *Proceedings of the Board of Agriculture in India held at Poona,* 1917, p. 26.

of the soil, the crops grown, and the nature of the sources of irrigation. But for typical canal-irrigated land in the Cawnpore and adjoining districts, eight acres of mixed farming probably represents the area which can be managed with a single pair of *good* cattle to advantage. With wheat and cotton as the principal cash crops, and with the usual percentage of irrigation—the more important subsidiary crops being *juar* (*A. Sorghum*) with *arhar* (*Cajanus indicus*), gram, maize and some barley —this area also enables a satisfactory supply of fodder to be grown and would allow of fair provision of grain for the cattle. Many much larger holdings carrying several ploughs are known to exist, and also many much smaller. How far the smaller holdings are really uneconomic, and how far they represent the Indian equivalent of "allotments" cultivated by labourers who are only partly dependent on them, it is difficult to say; but one's general impression is that it is only as the country develops and other outlets for labour arise that the holding below the economic size will vanish. The small holdings held by labourers will probably always remain. The desire of this class to obtain land is often intense, as it often affords practically their only chance of social betterment.

But a compact holding of eight, or even six, acres is a vastly better proposition than the present type of holding of this size. Even if we admit that drastic action to limit the minimum size of holdings is at present impossible, there is no reason why steps should not be taken to limit the evils of fragmentation. In the districts referred to above, there is a very large number of holdings of undoubted economic size, varying from eight to twenty acres, with a smaller number of larger holdings, all of which would be capable of really good working were they reasonably compact. Many large occupancy holdings exist, but few of them are worked to the best advantage, and considerable portions of many of them are sub-let. Whilst there are often other reasons for this, particularly in the case of some castes, the writer has often been told by the tenants-in-chief that the sub-letting is due to the difficulties of managing a scattered holding, particularly of providing for the watching of crops. Thus we have potential farms sub-let in bits and lose an asset of considerable importance.

The same difficulty arises with the land of cultivating zemindars. The number of zemindars who own considerable areas of *sir* or *khudkasht* land, which theoretically form their home farms, is large, and such men are an important asset in the introduction of agricultural improvements, since they generally possess some education, and have a certain amount of capital, besides being extremely influential in their own circle. But here again any attempt at farming, as distinct from the cultivation of a miscellaneous collection of fields, is rendered the more difficult by the scattered nature of the land and the difficulties encountered in any attempt at obtaining compact areas. The writer has come across several cases where small cultivating zemindars, in an attempt to obtain a compact bit of land, have taken up and brought into cultivation pieces of waste or grazing land and have sub-let their old *sir* land. Such opportunities are rare, however, as the districts mentioned are closely populated, and there is little culturable fallow except where irrigation is non-existent or precarious.

A small experiment in the Cawnpore District has given us definite data as to the possibilities of small home farms cultivated by their owners. With the assistance of the department, a small Kurmi zemindar devoted the whole of his *sir*, and also some rented land, aggregating approximately 40 acres, to the growing of improved varieties of crops with the methods of cultivation adopted on our seed farm. Profitable though this was, he was convinced, in the first year, of the waste of labour and unsatisfactory results which resulted from scattered fields. After some trouble and with a great deal of assistance from the Collector of the district and his staff, a compact area was obtained by voluntary exchange with other zamindars and cultivators, but this was only achieved by the former giving up some of his best land and taking in exchange a block of land more remote from the village site and assessed as much less valuable. The results amply vindicated the value of a compact holding. The Irrigation Department were at once able to render important assistance as regards water-supply, economy in management was immediately apparent, and the crops of Pusa wheat, Cawnpore-American cotton and other crops raised were in no way inferior to those on our own farms. On the owner's own showing, and after allotting himself

the usual rent on the land, the very useful *net* profit of Rs. 50 per acre was obtained. Unfortunately, under our present Rent Acts, it is not often possible to arrange compact holdings by agreement.

In discussions which have taken place on this subject, it has been impossible not to notice a feeling, on the part of some revenue officers, that the agricultural departments are going outside their own sphere in taking up a matter which they view as primarily economic, and that the departments would do better to restrict their energies to more purely technical matters. Were this view based on correct assumptions it would temporarily carry some weight, as the agricultural departments are admittedly under-staffed and already have on their hands as much as they can manage. Apart from the fact that all means of rural betterment must come eventually within the consideration of the departments charged with agricultural development, there is the more immediate point that fragmentation of holdings imposes distinct limits on the introduction of agricultural improvement. Whether it be the introduction of a new crop, new variety, or improved method, it should be possible—once the proposed improvement has been well worked out on an experimental farm and proof given that it can be profitably employed, and that it involves nothing beyond the means of a well-to-do cultivator—to proceed unhesitatingly with its introduction. This, however, is not the case. When farm testing is extended to village testing, failures occur as the result of conditions which ought not to exist. The writer has had under his notice several varieties of cotton with distinctly desirable commercial qualities and with apparently the necessary agricultural characters to ensure high yield, which, given ordinary decent cultivation on departmental farms, have yielded well enough, but which under village conditions, through water-logging caused by inadequate surface drainage, have done badly. This led to the conclusion that the local *desi* cotton possessed a certain degree of tolerance to water-logging which had not previously been considered of importance. Now the production of an improved staple crop is a sufficiently difficult and lengthy process as it is. The number of characters to be dealt with is considerable, and every additional character to be considered makes work more difficult and slower. If it is also

necessary to consider a somewhat indefinite character, which only appears under faulty conditions of cultivation, progress is further delayed. In many villages inadequate surface drainage is purely a matter of small and scattered fields. With compact, if small, holdings, great improvement would be possible at nominal cost. Is one not justified in attacking the problem from both ends ?

What has been said of cotton is equally true, though to a less marked extent, of wheat. An improved wheat is, in a sense, a more efficient machine, and unless it is given the cultivation necessary to achieve high yields, its full value will not be obtained. Nor can wheat of high milling quality be grown on ill-drained land. This point has been strikingly brought out by the result of crop cutting experiments on Pusa 12 wheat in villages. Instead of a possible yield of 30 maunds per acre on really fertile land and 25 maunds per acre on average land (as compared to the district's normal 16 maunds of *desi* wheat), many cultivators were getting only 19 maunds per acre, or one-third of the possible increase. In the same villages higher yields were being obtained on well-cultivated or well-situated fields. The effect on quality was almost as marked, though complicated by excessive irrigation in some cases.

Such examples could be multiplied. Scattered holdings usually mean small fields, and even if drainage is not interrupted, such fields are difficult to plough correctly or to cultivate well. One is justified in asking whether such changes in the tenancy laws are not possible in zemindari provinces, as will enable those who realize the advantages of compact holdings, to take steps to get them, and will reduce the present tendency to further fragmentation.

AGRICULTURE AND IRRIGATION: A PROBLEM OF ECONOMIC DEVELOPMENT.

BY

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"When I hear the simplicity of contrivance aimed at in any new political constitutions, I am at no loss to decide that the artificers are grossly ignorant of their trade, or totally negligent of their duty. It is better that the whole should be imperfectly answered than that, while some parts are provided for with great exactness, others might be totally neglected, or perhaps materially injured, by the over-care of a favourite member."—[*Burke's Reflections on the French Revolution.*]

The above observation is as much true of other institutions as of political. Civilization is getting more and more complex, and its component parts, and eventually the whole, suffer for want of co-ordination and neglect of the less favoured ones. The science of agriculture has long suffered from neglect. Up till very late, agriculture was supposed to be the business of the illiterate cultivator. I have no desire to find fault with the Indian cultivator for not knowing better. Indeed, it is a matter of surprise that, born and bred in ignorance, he yet contrives to be so successful in agriculture, by following the principles which have descended to him in an unbroken chain for thousands of years from his forefathers, but his primitive methods are unsuited to the present conditions of rapid development. India should be grateful to Lord Curzon for having created an Agricultural Department and encouraging research. The Indian States, too, have not been slow to follow in the wake of

the Government. I am not in the Agricultural Department and hence have no right to express any opinion about matters agricultural, but the relation between agriculture and irrigation is so intimate and indissoluble that my remarks, I trust, will not be considered out of place. Indeed, only on the establishment of correct relations between the departments of revenue, irrigation and agriculture, the economic development of our vast areas is possible. At present the three departments work, more or less, in water-tight compartments. Each regards the criticism of the others as meddlesome. Criticism is always valuable, but to achieve its ends it should be constructive. The attitude of armed neutrality, almost hostility, exhibited by these allied departments towards each other, is not unnatural under the existing rules and circumstances. That far-sighted statesman who would blend the activities of all these into one homogeneous whole has yet to come. It will be his duty to show that the best interests of every one of them can only be attained by co-operation and co-ordination.

Once upon a time the different members of the human body rebelled against the stomach. The eyes thought that the whole body would be useless without their service. The legs raised an uproar that if they refused to work the body would die of inanition. The hands similarly vociferated that the entire civilization was built by them. In short, each component part of the body asserted its importance, but all were agreed that the stomach was not only useless but a wasteful luxury. It consumed and appropriated the best of what the world could produce. All the rebels struck work and gloated on the discomfiture of the stomach. The poor stomach collapsed, but being wise held its peace. As it took no food, it could send no nourishment on to the different organs whose functions began to suffer. The eyes grew dim, the legs began to totter, the hands lost their nerve, and every limb was in distress. The rebels very soon came to their senses and realized that while all of them were doing their respective duties in the human economy, the stomach had its uses too, and that the well-being of the whole depended on the well-being of all the parts. This is a homely parable, but it applies in full force to the unco-ordinated and exclusive activities of the allied

departments of revenue, irrigation and agriculture. If the Revenue Department were to act more considerately in its dealings with its sister departments, and were more ready to accept the advice of irrigational and agricultural experts, and these, in their turn, accepted their interdependence on the Revenue Department, we would not see so many lakhs of acres lying uncultivated, and the present criminal waste of water and harrowing visitations of famine will become a thing of the past. The existing irrigated area in India is about 20 crores of acres. It does not require any effort of imagination to see that this could easily be doubled if the results of the researches of the agricultural experts were given due weight by the irrigation and revenue officers.

Plants are living organisms. They require food, water and air. The soil supplies the main portion of the food, irrigation works supply water, and the air is there in abundance if the cultivator only knew how and when to supply it to the roots. At present water is supposed to be the panacea of all evils. If the soil is poor, water is supposed to make it fertile. If there is excessive heat, water is called upon to reduce it. Water again is called into requisition to counteract the rigours of cold. Water does all this, but more is required than water. The roots require air as well. There is such a thing, Mr. Howard rightly says, as poisoning the roots with too much water. It will be unnecessary for me to dilate on this point, as this aspect of the subject has been well brought out by Mr. and Mrs. Howard of Pusa in their Bulletins,[1] which are important enough to be studied by every irrigation and revenue officer.

Over-irrigation and wasteful application of water produce harmful effects in several ways—

(1) by reduction in the yield of crops per acre;
(2) by impoverishment and deterioration of soil;
(3) by spoiling the climate, rendering it too humid and malarious;
(4) by rendering irrigation works less efficient and consequent loss of revenue.

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[1] *Agric. Res. Inst., Pusa, Bull. Nos. 52 and 61.*

Leaving aside the minor harms of over-irrigation, if we try to appraise the monetary value of the above factors only, it would, for India as a whole, run into millions of rupees. Over-irrigated crops yield about half of seasonably-irrigated ones. When we see that all irrigated area is more or less over-irrigated, this factor alone is potent in reducing the total outturn and, in consequence, the wealth of the country. The damage caused to the soil and to the future generations can only be realized on observing the condition of water-logged areas. The effect on climate cannot be expressed in money, but the loss to India of valuable lives by malaria is very great. Malaria is a slow and insidious disease, and does not attract that attention which cholera, plague and similar epidemics do, but it claims more victims annually than all of these put together! Is it not therefore worth our while to harken to the friendly voice of the agricultural experts, and modify our ways of irrigation and cultivation? I am not a theorist, and fully realize what this means. This means a revolution in our present methods of cultivation and irrigation; no more and no less. It would necessitate overhauling and remodelling the entire irrigation systems of India on which crores have been spent. This is a gigantic task, sufficient to stagger the imagination of the engineers; but if we want to develop India economically, the difficulty must be faced, and the sooner we do it the better. It will also give food for thought to the financiers. They might well grumble at having to loosen their purse strings, but the war has amply proved that parochial methods of financing are no longer tenable and must be discarded, and higher finance should be allowed full play if nations do not want to lag behind in the race of advancement. The present difficulties must not be allowed to cripple the future. Financing and construction of large irrigation works are, at present, considered apart from each other. This is incorrect. They must be considered together. Readers of this article will do well to study Professor Stanley Jevons' article on the "Art of Economic Development" in the January (1918) Number of the *Indian Journal of Economics*.

Engineers flushed with the success of their enterprises are rather impatient of criticism of their method from agriculturists, but if

the latter continue to follow their propaganda with persistency, it will not take them long to get a patient hearing and convince the engineers of the value of their researches.

Mr. Howard lays great stress on reducing the numbers and depths of waterings, and he has tried to show that if the soil is in proper tilth, and proper root-aeration and soil ventilation are carried out, it is quite possible to raise wheat on one watering in alluvial tracts. Much more so is it possible in black soils of Malwa, owing to their greater retentiveness. He is of opinion that this can automatically be achieved by supplying water by measurement. This is certainly the goal to be aimed at, but I am afraid it would be too early for the primitive conditions of India, where the agricultural classes are illiterate and ignorant. It is carried out in America and has proved a great success, not only in economizing waste of water, but in reclaiming water-logged tracts.

Up till very late, it was usual in Gwalior to allow for a duty of 20 bighas (10 acres) per million cubic feet of the water stored. This included all loss in transit and worked out to a depth of 26 inches. This was of course very rough and encouraged waste in application, for as long as the staff attained this duty, their work was considered satisfactory; but recently, with a view to minimize loss in application and to arrive at a juster estimate of the irrigation possibilities of our works, I have laid down the following scale, which is only applicable for small projects with length of channels up to 10 miles :—

Table showing the duties of one million cubic feet of water for different crops.

Serial No.	Name of crop	Duty per million cubic feet			Remarks
		Impervious soils	Loamy soils	Sandy porous soils	
		Bighas	Bighas	Bighas	
	A. Kharif				
1	Rice	30	20	10	
2	Cotton	90	60	45	
	B. Rabi				
3	Wheat	65	40	20	
4	Gram and other pulses ...	180	125	70	
	C. Perennial				
5	Sugarcane and gardens ...	15	10	5	

For large projects, with lengths of channels ranging from 10 to 100 miles, a different procedure is adopted. Before determining the carrying capacity of the main canal and its distributaries, it is, in view of local conditions, fixed what proportions of different crops will be developed in the tract under consideration. This, of course, is a rough approximation, but answers all practical requirements. The proportion having been settled, the quantity of water for *kharif* and *rabi* crops is worked out from the following standard numbers and depths of waterings. As far as possible, the *kharif* and *rabi* crops are so balanced that they require about the same discharge. As the Gwalior canals work alternately from June to October for *kharif*, and October to March for *rabi* crops, it is evident that the capacity of maximum economy is attained by balancing the *kharif* and *rabi* discharges :—

Standard numbers and depths of waterings.

Name of crop	No. of waterings		Depth of waterings		Remarks
	Impervious clay	Porous loam	Impervious clay	Porous loam	
1. *Kharif*—					
(*a*) Rice ...	4	8	2″	4″	The waterings in the *kharif* seasons are in addition to water supplied by rains.
(*b*) Sugarcane ...	4	6	2″	4″	
(*c*) Cotton ...	2	3	1½″	2″	
2. *Rabi*—					
(*a*) Wheat ...	2	4	2″	3″	
(*b*) Gram ...	1	2	1½″	2″	
(*c*) Sugarcane ...	5	8	2″	3″	

The above depths of waterings are on the fields. Loss in transit on large canals is considerable. On the basis of experience acquired in the Punjab, the loss for evaporation and absorption is allowed for at the rate of 10 cusecs per million square feet of wetted area. It is hoped that with the introduction of this procedure, of a more careful supervision and encouragement of a single watering, it will be possible to greatly reduce waste in Gwalior canals and increase their efficiency. That this is working satisfactorily is clear from experience gained on the Bhind canal. The storages of the Sank-Assan scheme aggregate to 10,000 million cubic feet. Mr. Preston considered these would suffice to irrigate one lakh bighas or

50,000 acres. This gives a theoretical duty of 10 bighas per million cubic feet, but during the last three years the duty attained is about double of this.

Charging by measurement in India is a bit too early. The nearest approach to it is charging by the number of waterings. In the British provinces, the Irrigation Department charge for crops matured. In the Irrigation Act of Gwalior, the State has wisely, at my recommendation, allowed charging 8 annas per bigha for a single watering. In black soil tracts, irrigation is unpopular, as owing to their retentiveness no watering is generally necessary for *rabi* crops, and in years in which the rainfall is not well distributed, or fails in October or in winter, one watering is needed. The irrigator is averse to pay R. 1-8 for one watering. The provision of 8 annas for a single watering comes in very handy and is slowly leading to the extension of irrigation in Malwa. In Irrigation Paper No. 15 ("Development of high class crops in black cotton soils in Malwa"), I have tried to explain to the revenue officers and the cultivator that the *raison d'être* of the irrigation works is not merely to mature *kharif* and *rabi* crops, but (1) to provide water for domestic and drinking purposes, as there are no sub-soil springs; (2) to supplement rainfall in years of drought; (3) to raise high class crops like sugarcane, paddy and opium, requiring not only a larger number of waterings but water at the fag end of the irrigation season (May or June), when water can only be had from irrigation works; and (4) to increase the yield per bigha and improve the quality of *kharif* and *rabi* crops. I have attempted to show in that paper that because *rabi* and *kharif* crops of inferior sorts can be raised without artificial irrigation, it is no argument against other legitimate and more paying uses of water. It is difficult to pierce the thick skin of the Indian cultivator, especially as it is covered with a layer of ignorance of ages; but he is shrewd enough to understand what touches his pocket. This is why the advantage of paying 8 annas per watering is slowly sinking into his consciousness, and he is taking more and more water, not because my arguments have convinced him, but because he sees that it is to his advantage to extend irrigation by comparing the results of single-irrigated fields with those of the non-irrigated

ones. The advantage of a single watering would be more in evidence if he knew something about the soil atmosphere and the necessity of soil-aeration and root-ventilation. This is partly done by Nature in Malwa, as the black cotton soil gets badly cracked and permits air penetrating to the roots. This quality of fissuring, perhaps, accounts more for the proverbial fertility of black cotton soils of Malwa than any inherent quality.

This subject is a vast one and would require a volume to do justice to it. I have in this short article endeavoured to merely break ground. We have much to do. It is high time the activities of the allied departments of revenue, irrigation and agriculture were correlated to the great improvement of agriculture, amelioration of the condition of the ryot, and general increase in the wealth of the country.

FREQUENT FAILURE OF A LARGE PROPORTION OF THE RICE CROP IN CHOTA NAGPUR.*

BY

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THIS paper refers primarily to the Ranchi District, but is applicable to other large areas of Chota Nagpur where the physical conditions are similar.

The Ranchi District consists, in the main, of plateaus at three elevations, 1,000, 2,000 and 2,500 feet, respectively, above sea-level. The area of the district is over 7,000 square miles, and the average rainfall about 53 inches, of which some 45 inches fall within four months.

The soil of the uplands appears to be derived *in situ* from the weathering of the gneiss which forms the great mass of the rock of the plateaus, and consists for the most part of clay in which particles of coarse sand are embedded. When the fine particles of clay are washed out of the surface soil the residue is distinctly sandy, and acts as a superficial reservoir in which a considerable part of each monsoon shower is held and enabled to soak at leisure into the less pervious sub-soil, whence it can only escape laterally over the compact rock below.

This lateral movement is very slow, and a ridge of any considerable dimensions holds enough water in the sub-soil to supply springs in the valleys round it throughout the year, while in the monsoon the water frequently comes to the surface at a comparatively short

* A paper read at the Sixth Indian Science Congress, Bombay, January, 1919.

distance from the crest of the ridge, on land that appears to the casual observer remarkably high and well drained.

The soil conditions present a marked contrast in this respect to those of alluvial plains where the coarser and more pervious layers having been deposited first are found, generally speaking, below, and the finer and less pervious layers above, with the result that lateral drainage is more rapid in the lower strata, the sub-soil water rising and falling with the level of the rivers with which it is in reciprocal relations.

In Chota Nagpur, wells depend on the local rainfall, though they are frequently sunk into the weathering gneiss until it becomes so compact that further sinking is obviously useless.

The graph opposite shows the rainfall and the corresponding variation in the water-level in a well on high sloping ground on the Ranchi Farm. During September, October, and part of November, 1917, the distance of the surface of the water from the top of the well was measured daily. The immediate rise of the water-level after rain is remarkable and may amount to five times the rainfall, as for instance on 19th and 20th September, 1917, when the water in the well rose $22\frac{1}{2}$ inches as a result of 4·28 inches of rain. On the other hand, the rate of fall even from a high level is comparatively slow—$38\frac{1}{2}$ inches in 30 days without rain in November, the monsoon having continued up to the very end of October.

As will be seen later, this slow fall of the sub-soil water-level is a point of some importance in connection with the protection of the paddy crop against drought.

Another point of interest is the rapid rise of the water-level at the beginning of the monsoon—6 feet from 12 inches of rain in June, 1917, and 10 feet from 20 inches of rain in June, 1918. This may be partly due to the filling to overflowing of a tank within 200 yards diagonally across the slope.

When the sub-soil water-level is close to the surface over large areas in the latter half of the monsoon, heavy showers are unable to soak in to any considerable extent, and the water escapes almost immediately over the surface to the lower levels, eroding the valleys and causing sudden floods such as those of the Damodar which

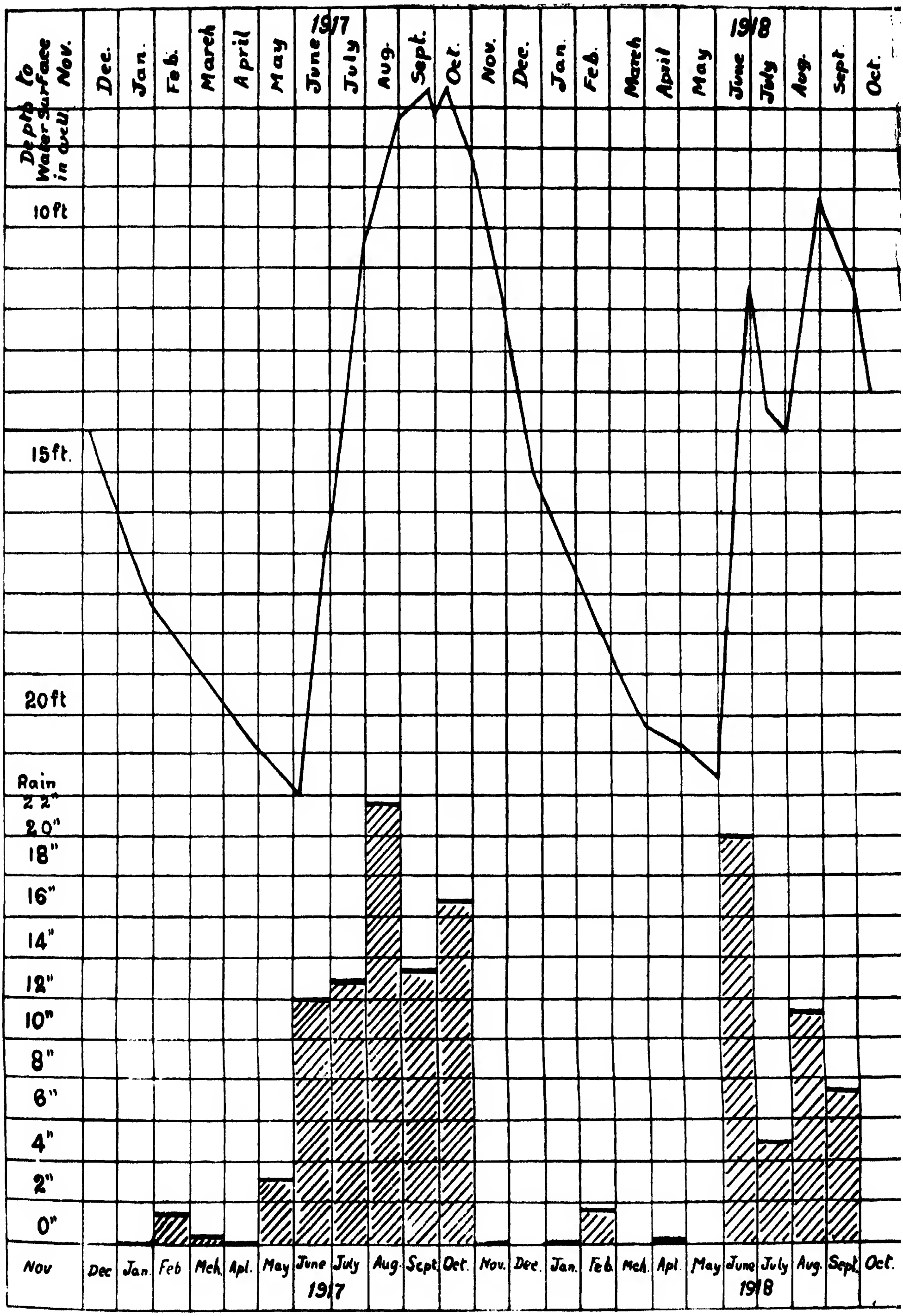

Chart comparing the rise in the water—level in a well on the Ranchi Farm with the rainfall, November, 1916, to October, 1918.

Scale.—Water surface from top of well 1"=40"
Rainfall . . . . . 1"=8"

drains the greater part of the Hazaribagh and a corner of the Ranchi plateaus.

The comparatively level winding grooves ground out of the general level by this great volume of water charged with quartz sand, open out through deep nullahs and narrow valleys into scalloped basins on the surface of the plateau, separated by ridges and

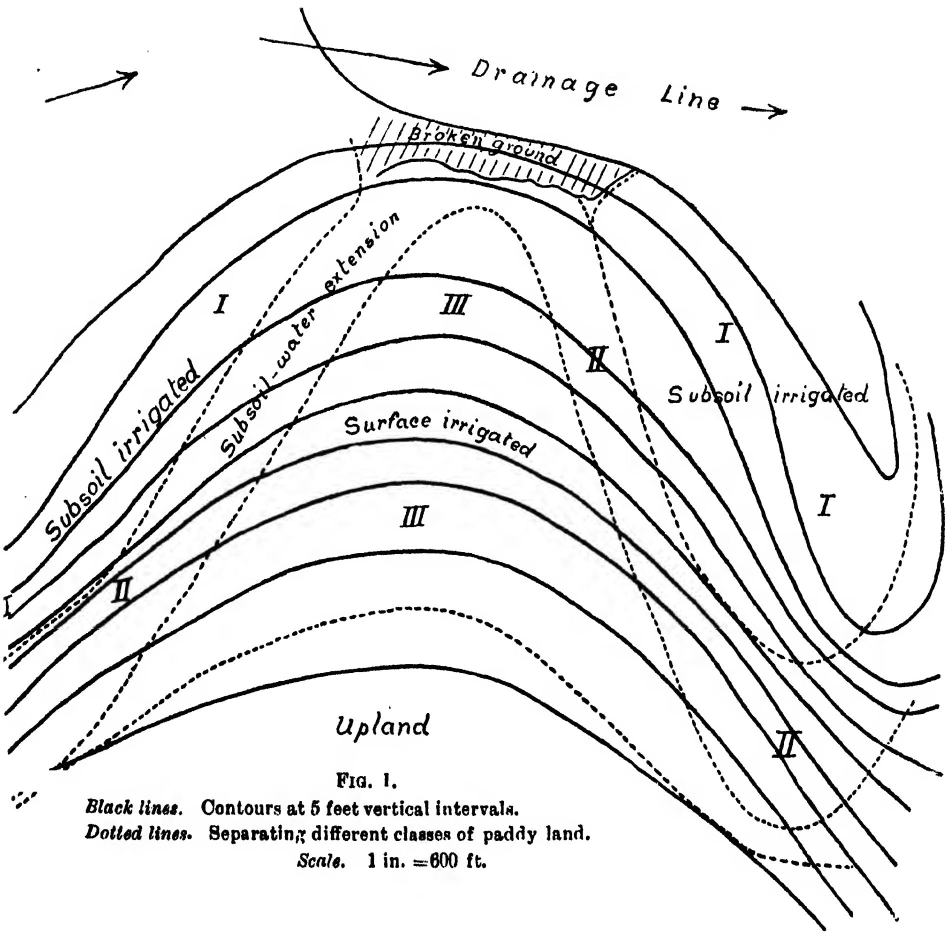

Fig. 1.
Black lines. Contours at 5 feet vertical intervals.
Dotted lines. Separating different classes of paddy land.
Scale. 1 in. = 600 ft.

bluffs none of which extend laterally for more than half a mile or so from the nearest distinct drainage line. The diagram, Fig. 1, illustrates a very general arrangement of the contour lines on a bluff,

and Fig. 2 the position of the sub-soil water surface relative to that of the ground at the end of the monsoon. Vertical distances have,

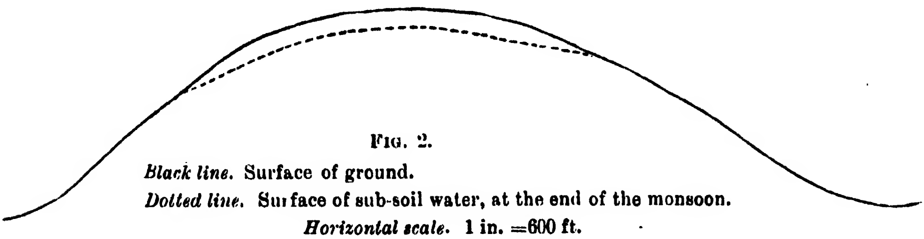

FIG. 2.

Black line. Surface of ground.

Dotted line. Surface of sub-soil water, at the end of the monsoon.

Horizontal scale. 1 in. =600 ft.

Vertical scale. 1 in. =30 ft.

of course, been greatly exaggerated to enable the eye to appreciate differences in level, which in reality rarely exceed 1 in 10 even on the most steeply terraced land.

It will be noticed that the dotted line representing the sub-soil water surface at the end of the monsoon in Fig. 2, comes to the surface of the ground at points somewhat above the points of maximum inclination of the slope, where the convex surface of the bluff merges into the concave surface of the basin on either side. The sub-soil water comes perforce to the surface in the neighbourhood of these points, where the disintegrating upper strata, through which the water must flow over the rocky core of the bluff, have been reduced to a minimum thickness by the rush of water from the relatively level surface above to the relatively level surface below.

The line where the sub-soil water emerges on the surface—in fact the spring-level—towards the end of a normal monsoon, marks what may be called the natural upper limit of paddy cultivation in Chota Nagpur. Starting at the head of each valley basin, the line runs down the sides of the bluff, on either hand cutting the contour lines at a considerable angle and emerging in the valley below as the bluff narrows to its apex.

A short distance below this line winter paddy may be grown with safety, in the assurance that the water stored in the sub-soil of the bluff above will rarely fail to maintain a steady supply up to November on the surface below.

Cultivators have, however, terraced the surfaces of the bluffs above this line up to a second line cutting the contours at a smaller angle and frequently encircling the bluff above its apex. Hardly anywhere in the Ranchi District have tanks been made in which water might be stored for irrigating these higher terraces, and, situated above the level of the sub-soil water in a normal season, they depend for flooding on the rain-water running off the upland and, at a lower level, on the surplus water from the higher terraces across the slope ; and they dry with every break in the monsoon. This area normally grows a light crop of early varieties of paddy which flower at the end of September and ripen off rapidly when the land dries, usually in October, but which suffer severely from any curtailment of their short growing season, and give practically no crop if the land cracks before they flower and is not quickly flooded again.

We have then two distinct classes of terraced paddy land in Chota Nagpur—the sub-soil-irrigated area which can be relied on to give a fair crop of winter paddy on the concave surfaces of the valley basins, and the surface-irrigated area which grows a small precarious crop of early varieties on the lower portions of the convex surfaces of the bluffs. Between these two areas, at about the normal monsoon level of the sub-soil water, lies a belt which may be described as the sub-soil-water-extension area, over which the sub-soil water is maintained at a high level by the storage of water in the fields themselves and on the surface-irrigated area immediately above.

This belt usually lies on a more or less plane surface and, where the slope is gentle, may be of considerable width ; it grows early winter paddies the yield of which is subject to considerable but rarely extreme fluctuations according to the character of the season, the land being kept moist after the close of the monsoon by the water percolating slowly from the sub-soil behind.

These three classes of land are separated in Fig. 1, from one another and from the upland by dotted lines, and are marked I, II and III from the lowest upwards.

In the Settlement Report of the Ranchi District, written by Mr. J. Reid, I.C.S., and from which all the statistics quoted in this paper have been taken, the terraced or "Don" paddy land

is divided into four classes. The lowest of these, which grows two crops in the year, is classified as Don I and is said to cover an insignificant area of 760 acres in the whole district. This with Don II, which is said to grow the winter crop cut at the end of November, presumably covers the greater part of the area referred to here as sub-soil-irrigated : Don III, said to grow the crop cut early in November, seems to correspond with the intermediate belt which has been described as the sub-soil-water-extension area ; and Don IV, the crop on which is cut in October, must represent the surface-irrigated area which dries immediately after the monsoon ends.

Neglecting Don I as insignificant, the respective cropping power of these classes of land is estimated at 19, 15 and 9 mds. (of 80 lb.) to the acre in a normal season.

Now in a year like the present when the monsoon ends before the middle of September while the temperature is still high, the whole of the surface-irrigated area (III) dries to the point of cracking within about a fortnight, before even the earliest paddy flowers, and the crop on this area is practically a complete failure. Moreover, the intermediate belt (II), though drying comparatively slowly, carries a later crop and suffers to a less degree only, and as it normally gives a much heavier yield than the higher terraces the absolute loss per acre may be as great or even greater. Again the sub-soil-irrigated area (I), though rarely suffering from absolute drought, carries a still later and heavier crop which, in extreme cases, even if the lower half be entirely unaffected, must give a considerably smaller absolute yield along its upper margin.

The combined areas of Dons I and II (I) is, however, estimated at only 284,000 acres in the Ranchi District, while that of Dons III and IV (II and III) is 489,000 acres ; so that a partial failure of part of the crop on the lower land cannot do more than aggravate a situation that must be already serious. For, supposing that practically the whole normal crop of 9 maunds per acre on III is lost and also half of the crop of 15 maunds on II, we have a reduction of over 8 maunds per acre on 489,000 acres, or about 4 million maunds out of a total normal estimated production of 12¼ million maunds of paddy of all kinds, of which total some ¼ million maunds is exported.

Deducting a dead-weight of about a million maunds required for seed purposes, we find that the amount of paddy available for food purposes may be reduced from $11\frac{1}{4}$ million to $7\frac{1}{4}$ million maunds by the reduction of the crop on areas II and III alone, simply owing to an abnormally early closing of the monsoon even if the season has been otherwise favourable.

As the value of the paddy crop is estimated at 140 out of the 196 lakhs of rupees which represent the total value of the crops of the district, and as the aboriginal cultivators have practically no reserves, it can readily be believed that scarcity amounting to famine must prevail in many parts of Chota Nagpur under these circumstances. This is in fact frequently the case. To quote from the Settlement Report already referred to, "There was scarcity, if not famine, throughout great parts of the district in the years 1896, 1897, 1900, and again in 1908......The cause was in all cases the same, *viz.*, the early cessation of the monsoon."

Scarcity must, therefore, be described as of common occurrence, and it is liable to be greatly aggravated by the vagaries that are common in an abnormal monsoon. For instance, in the season that has just closed, drought up to the end of May and excessive rain (20 inches) in the first four weeks of June prevented the normal broadcast sowing of half the paddy area, and it was sown late and on wet land. The same was the case with the seed beds. This was followed by seven weeks with a total of less than $8\frac{1}{2}$ inches of rain, during which transplanting was only possible on an insignificant area. The whole paddy area therefore started about a month late and would in any case not have given more than two-thirds of the normal crop, even on the lowest land, while the crop on the intermediate area (II) and on the higher of the terraces below it, was only just coming into flower when the land began to crack, and in many places was not much better than the total failure on the higher terraces.

That such common and comparatively small fluctuations of the monsoon should have such a serious effect on the food supply of the district, is due primarily to the fact that the fluctuations are irregular and cannot at present be foreseen. The increasing accuracy of the monsoon forecasts gives some hope that it may

ultimately be possible to adjust the sowing of early and late varieties of paddy, so that their flowering may in all cases precede the retirement of the monsoon. But common prudence suggests that it is foolish to continue to grow a very large proportion of the food supply under the artificial conditions implied by the sowing of a water-loving plant on land subject to sudden drought, without providing some means of supplying water for the comparatively short periods during which an artificial supply is commonly required even in a normal season.

As mentioned before, there are very few tanks and there are no natural lakes in the Ranchi District. That this is so is probably due partly to the generally steep gradients, which necessitate the making of very high embankments to retain any considerable areas of water. So far as Government action is concerned, sites where large tanks could be made with economy are not easy to find, and the equitable distribution of water on relatively small areas is full of administrative difficulties.

But if the safety of the paddy crop depends primarily on the maintenance of the sub-soil water at a high level in the bluffs, as the considerations detailed here indicate, it is not a few large tanks at the heads of valleys that are required, but a general distribution of small tanks along the slopes. And the function of these tanks would be not directly to irrigate the surface, but to hold up the water so that it would soak by itself into the fields below, through the sub-soil, without any necessity for regulation.

This is, in fact, the normal function of tanks in Chota Nagpur. They do not commonly hold water for any length of time above the sub-soil water-level, and are rarely used for irrigation in the ordinary way, but there is always a stream of water running out of the paddy fields immediately below them.

Beyond providing an emergency outlet at a high level it would therefore be unnecessary to take any steps to regulate the escape of the water, the distribution of the tanks thus solving most of the difficulties of administration.

The effect of such a tank, filled intermittently by monsoon showers, and leaking continuously into the sub-soil on all sides, is to

raise the sub-soil water-level both above and below it, and thus to provide, in the sub-soil, an additional reserve of water, which lasts for a much longer period than that for which the water held in the tank itself at any one time would suffice. This is well illustrated both by the rapid rise and slow fall of the water in the well already referred to, and, in a more practical and convincing way, by the case of another tank on the Ranchi Farm, made by running a *bandh* across the lower side of a recessed paddy field surrounded by upland on the other three sides. Three or four inches of rain, falling in heavy showers at the beginning of the monsoon, fill this tank to a depth of about three feet. This disappears completely in about a fortnight if there be no further rain ; at the same time the water comes to the surface in the paddy fields below the tank which are completely dry in the hot weather. At the end of the recent monsoon the water fell to a depth of 3 ft. 8 in. below the outlet during 36 days of drought with a west wind, the level being maintained by visible percolation from the sub-soil above the tank. The rate of fall was thus almost exactly the same as that of the water in the well after the close of the previous monsoon.

Given a sufficient total rainfall, the maintenance of the sub-soil water-level for three or four weeks of dry weather, at a height sufficient to flood all the paddy fields, is therefore merely a question of holding up a sufficient quantity of the water of every monsoon shower, at a high level, immediately above the area to be protected. Experience on the Ranchi Farm seems to show that to fill up the sub-soil in the course of two months with a combined rainfall of about 20 inches, it is only necessary to hold up about 4 inches at any one time of the rainfall from over the collecting area. Assuming a radius of 500 yards of upland on the bluff, tanks 100 feet wide round the perimeter would be required to hold less than 5 feet depth of water for this purpose, and a 7-foot *bandh* would be sufficient—to be raised later if experience showed that it would be economical to do so. If a row of narrow tanks were made along the edge of the upland above the highest series of paddy fields, by excavating part of the slope to make a series of *bandhs* within 100 feet of the excavation, and in echelon along the slope, these tanks would go a

long way towards tiding the paddy over the short periods of drought that are now so disastrous. Earth can be excavated and carried within a distance of 100 feet at a cost of 4½ annas per 100 cub. ft. in the Ranchi District, and a *bandh* 7 feet high and 21 feet wide at the base, with the necessary cross *bandhs* between the successive levels, could probably be made at a cost of annas 5 per running foot of tank.

The benefit would not be confined to the saving of the crop on the higher terraces in case of an early cessation of the rains, but by supplying water throughout any probable break in the monsoon and by enabling later and heavier yielding paddies to be grown with safety on the intermediate terraces, such a series of tanks would increase the crop over the whole commanded area by an amount that can hardly be put at less than 4 maunds an acre on an average of years. Taking the value of paddy at Rs. 2 a maund a simple calculation shows that an expenditure of Rs. 100 on 320 feet length of tank, involving an annual charge of, say, Rs. 20 for interest and repairs, would be justified by an average breadth of 350 feet of the area commanded.

The actual breadth of the paddy belt round the sides of a bluff is commonly very much greater than this, while there are wide expanses which though they could not be thoroughly protected without much greater expenditure, would give a greater proportional return for such partial protection.

Such protection being therefore well within the bounds of economic possibility it may be worth adding a few suggestions as to details and incidental possibilities.

A series of these narrow tanks would extend from the valley head on each side of a bluff, and would meet at some point above the apex of the bluff. If each tank were provided with a wide emergency outlet into the paddy field above and behind it and below the previous tank in the series, and were connected with the next lower tank by a narrow deeper cut for lesser showers, the run off from the collecting area could be effectively controlled by ensuring that a sufficient proportion drained into the higher tanks of the series. The proportion of water escaping through the several

emergency outlets would be relatively unimportant, as they would only run when the rainfall was sufficient to flood the whole area to excess. There should be no difficulty in controlling on a wide convex surface the surplus water that at present does no very serious damage though concentrated in a narrow concave valley.

Roads provided with emergency outlets at any convenient intervals could eventually be run along the lower faces of the series of *bandhs*.

When it was desired to increase the capacity of the tanks, the earth excavated, if not required for raising the *bandh*, could be distributed over a strip of the upland above the tank so as to level it and raise it to a higher level above the water. These strips with water at a high level in the sub-soil at the end of the monsoon, and well drained, would be valuable for cold weather crops.

The general control of the rainfall of Chota Nagpur, in detail, in this way, would bring within reach the possibility of utilizing some of the power that is now wasted in the uncontrolled rush of water from an average height of 2,000 feet on the plateaus to sea-level. Supposing that half of the 45 inches of monsoon rainfall evaporates or is transpired by vegetation, and remembering that the whole of what soaks into the surface re-appears on the surface a few feet lower down, and supposing that only 500 feet of the total fall could be used effectively, the power retrievable from the Ranchi District alone would average over 1¼ million horse-power for six months of the year.

THE IMPORTANCE OF THE DEVELOPMENT OF THE DAIRY INDUSTRY IN INDIA.*

BY

W. SMITH,

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THE broad problem lying at the root of progress in India may be said to be the increase of the wealth-earning power of the masses and the ensuring of the benefits of this increased wealth to those who earn it, or, in other words, the increase in the wealth-producing capacity of the man in the field, and the prevention of the grabbing of this increase by parasitical classes who do not help to earn it. India is mainly an agricultural country, and to advance its real prosperity not only must the wealth-earning capacity of the cultivator be increased, but the productive capacity of the soil must be enlarged and the agricultural resources of the country developed. I know of no sphere of agricultural development which offers such a promising field in this direction as the development of the great dairying industry, because, as I hope to show later, the progress or otherwise of this industry very seriously affects the greatest of all agricultural problems in this country—the cattle-breeding problem. The wisest of Eastern monarchs has left it on record that " much increase is due to the strength of the ox ", and this three-thousand-year-old maxim may be taken as doubly applicable to India to-day. Every agricultural operation in this country, right up to and including the transport of produce to the rail, is dependant on the strength of the ox, and it follows that every addition we can make to the strength and efficiency of this animal is a direct increase to the wealth of the country, and, if we can eliminate the money-lender, a

* A paper read at the Sixth Indian Science Congress, Bombay, January, 1919.

corresponding advance in the standard of living of the man who owns and works the ox.

It is my opinion, based on thirteen years' close contact with cattle-breeding in all parts of this country; that the strength of the ox is decreasing in India, and that the country to-day does not breed the same quality of milk and draught stock it produced twelve to fourteen years ago. This is due to a variety of causes, but principally, I believe, to the conserving of many of the old cattle-breeding jungles as forest reserves, and the spread of the canal irrigation system, thereby converting what were formerly cattle-breeding jungles into grain-producing areas. If this be so, and I think the fact is generally admitted by those who have studied the subject, then there is only one remedy, which every other country has had to adopt when it met a like problem, *viz.*, the cattle must be bred on the cultivated lands. This can only be done and will only be done when it is economically sound for the cultivator to breed and rear cattle, and it is in order to make the breeding of cattle a payable proposition that the dairy industry must be developed.

I have heard it stated by those in authority in India that you cannot produce a good class of draught bullock out of a first class milch cow. My experience does not confirm this; rather I maintain that you cannot possibly produce the very best class of draught bullock out of anything but a really good milking cow. The ability to produce milk, Nature's all suitable food for the young, is the strongest and best proof of maternity, and the more efficient and perfect the dam, the more vigorous and healthy the offspring. The quality of yielding milk in no way clashes with draught points, and it can be proved that not only is there no antagonism between first class draught qualities and the giving of milk, but they are identical, and I quote the following well known instances where the very best class of milch cows and draught bullocks are produced from the same stock. In Northern and Central Sweden where most of the agricultural work is done by oxen, the favourite breed is the Ayrshire, and in Southern Sweden where the same procedure is followed, the Holstein is the most popular. These two breeds are probably the finest milk producers in the world to-day and their male stock make

most excellent field bullocks. Again the light yellowish brown Swiss cattle of the Jura district are famous as milkers, and their male calves bring very high prices and are specially reared and exported for agricultural work in the vineyards of the Rhone valley. If therefore from the same dam we can produce the best draught cattle of any type required, from the heavy milkers of that particular type, it follows that the primary essential for successful cattle-breeding in India is the development of the dairying industry. To make it economically advantageous for the cultivator or the grazier to breed and rear cattle, they must first obtain and breed from the profitable milch cow. Not only so but given the good milker, the income of the breeder must be assured from both sides, *i.e.*, the technical business part of the dairying industry must be developed so that the cow owner may manufacture and sell to advantage the milk or milk products from his cow, as well as the male progeny which will become the draught animal of the future. It is in connection with the development of the technical and business side of dairying that the most successful results have been obtained in the application of co-operative methods to productive agriculture. In most countries of the world which have a peasantry who cultivate their own lands, the manufacturing and distributing side of the dairy industry is done on co-operative lines, and the result has been that not only do the small cow owners reap the whole of the benefits of their industry, but the educative and moral effect of co-operative association in this class of business has been of great value in teaching the small farmers business methods, the value of combination, and in time eliminating the usurer. I know of no reason why the same results should not follow the development of co-operative dairying in India, and if by means of co-operative dairying the Sowcar or Gombeen man of the East can be eliminated and the actual producer get the great part of the fruits of his labour, this is in itself a strong reason for the necessity of the advancement of the industry in India.

As things are now in many cases, the cow is useless for anything but dropping a male calf, and as it may be assumed that half of the animals born yearly will be males and half females, the greater part

of the female stock born are an incubus on the land and in breeding parlance "eat their heads off." In short, as cattle-breeding in India must in the future be done by the cultivator it cannot be made really profitable outside of the dual purpose cow, producing milk in the case of the female and efficient draught qualities in the case of the male. No other system is practicable, as heifers not required for breeding cannot be sold for beef in India, nor can they in many cases be killed off as useless. In districts where male buffaloes are suitable for draught the same argument applies.

Every agricultural operation in India depends to some extent on the efficiency of the draught ox. This efficiency can only be increased and secured by the development and the fostering of breeding on dual purpose lines, *i.e.*, dairying and draught. From this point of view the development of dairying in India is of paramount importance, but there are other important reasons why the dairy industry in this country must be fostered, and of these I purpose to touch on two only, *viz.*, (1) the necessity for cheap and plentiful supply of dairy produce as a food of the people and (2) the value of dairying as a means of maintaining the fertility of the soil where general farming is practised.

As regards (1), India is a vegetarian country, the people generally do not eat meat, and I do not think there is anything which can take the place of *ghee* and the various products made from milk, either evaporated or curdled, as wholesome, strengthening and easily assimilated foods for the people, to say nothing of the absolute necessity for fresh milk for children and aged and infirm persons. The children of the nation are the hope of the future, and in these modern days, when the mother is so often unable to suckle her offspring, a cheap, pure and plentiful milk supply will go a long way to reduce the heavy infant mortality in cities and large villages. At the present time in most large cities and many Indian villages, pure milk is a luxury of the rich whereas it ought to be the common food of the poor, and from the point of view of the health of the people at large and their food supply generally, the importance of the development of the dairying industry in India cannot be overstated. There is no nation in the world whose people appreciate the product

of the cow so much as the people of India and yet to-day Indian cows generally are 100 per cent. less efficient as milk producers than those of most civilized countries. That they can in time be made more efficient is a certainty, and it is a truism that the efficiency of the dairy cows of any country is a true indication of the general agricultural advancement of that country.

As regards (2), the problem in front of the agriculturist in India, especially in the irrigated areas where failure of rainfall does not enforce frequent fallow years, is how to best restore the nitrogen, potash, and phosphates to the soil which the crops have removed, and there is no doubt that the development of dairying amongst the cultivators would, to a large extent, solve this problem. The land suffers in India from the want of what may be classed as mixed farming, and until the man who tills the soil gets into the habit of rearing and keeping cattle on his land, which can only be profitably done on dairying lines, there is no hope of his adequately manuring the land. If every cultivator fed a large part of the fodder grown on his land and a small part of the grain he produced, to cattle housed on the land, the manure from the cattle, if carefully husbanded and scientifically applied, would greatly enhance the general richness of the soil and increase its productive capacity. It may be said here that the practice of burning manure so common in India would prevent this, but this factor also can only be altered on economic lines, and I believe that the introduction of general dairying would go a long way to prove to the cultivator that the value of cowdung as a manure was in many cases greater than its fuel value, and in any case it would increase the quantity available so that an appreciable quantity would be left for manure after meeting fuel requirements.

To sum up, from an agricultural point of view the development of the dairy industry in India is of the greatest importance because—

(1) only by this means can the greatest of all agricultural problems in India, the cattle-breeding problem, be placed on a sound economic basis ;

(2) it particularly tends itself to development on co-operative lines ; agricultural co-operation has been the business

salvation of the small holder in many countries and it should be so in India ;

(3) the solving of the cattle-breeding problem on dairying lines must at the same time enormously increase the productivity of the land as the farmer will breed, rear and feed his own animal on his own land, and their manure will be available to renew the fertility of the soil year by year.

From a general point of view, as apart from the purely agricultural aspect of the question, there remains the great and far-reaching effect of the development of this industry on the health of the common people. Cheap and pure dairy produce is essential to the health of the community, they cannot get it now, and nothing but the development of dairying as a national industry will give it to them.

A DISEASE OF THE PARA RUBBER TREE, CAUSED BY *PHYTOPHTHORA MEADII*, McR.

BY

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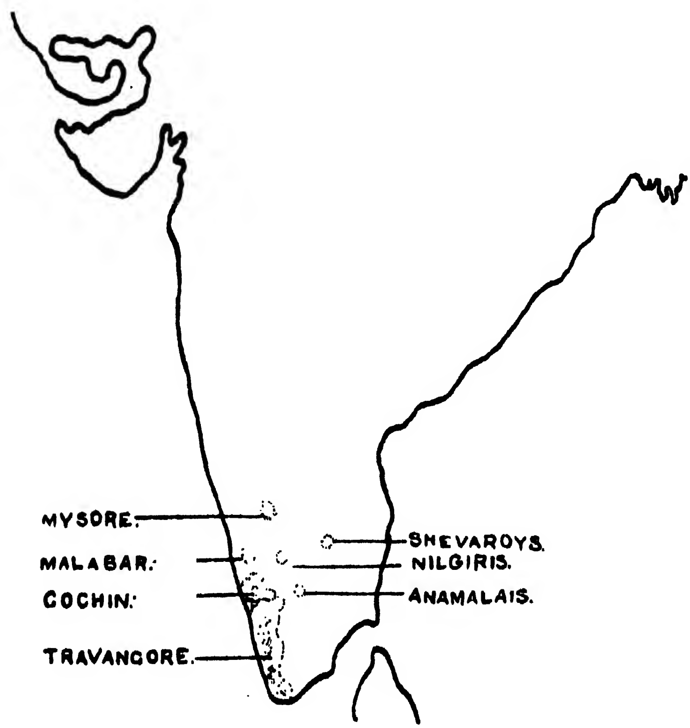
In India the Para rubber tree, *Hevea brasiliensis*, is grown chiefly in the south-western region of the peninsula along the outer fringe of the Western Ghats from the southern part of Travancore through Cochin State to the northern part of the district of Malabar, as well as in a few more inland localities in the Anamalai, Nilgiri, and Shevaroy Hills, in Coorg and in North Mysore where it is grown



Map showing the position of the rubber-growing area.

at higher elevation in a climate not usually considered particularly favourable. The estates occupy the flat land in the upper parts of the valleys and the lower slopes of the foot-hills, and individual estates or groups of estates are separated from one another by vast stretches of forest and jungle. The area of these blocks of *Hevea* grown as a pure crop varies from 100 acres or so up to 10,000 acres. Leaving out two small groups of trees planted experimentally by the Forest Department about 1879 and 1886 and single trees and groups of half a dozen in compounds and gardens, the first *Hevea* was planted under estate conditions in 1903, and during recent years it has been planted rapidly and now there are about 60,000 acres of which over half is in full bearing.

Rainfall.

The annual rainfall in this area is always high, being about 120 to 140 inches on most estates while reaching as much as 240 inches on some, and about two-thirds of this comes during the months from June to September. The south-west monsoon usually bursts early in June, after which it rains more or less continuously for the next three months. During October and November a fair amount of rain falls under the influence of the returning north-east monsoon, the precipitation occurring as heavy showers. From December to March there is little rain and the weather is comparatively dry and hot, whilst during April and May there are occasional showers which are connected with cyclonic disturbances. On the whole, then, the climate is warm and moist with the exception of a spell of hot weather when the humidity is comparatively low. Thus the conditions are eminently suitable for the growth of the fungus that causes the disease which is the subject of this note.

Early notice of the disease.

During the increased activity of planting in 1909-1910, while the planters were trying to meet the large demand partly from the older estates, their attention was directed to the fact that considerable numbers of fruits were rotten on the trees. Then too it was noted that there was some shedding of leaves during the

monsoon in addition to the normal leaf-fall that took place in the dry weather. When the demand for seed subsided, however, less attention was paid to these two phenomena. Again about 1913, when efforts were being made to utilize rubber seeds for the extraction of oil, attention was directed to the fruit-rot. Still as the demand for seed for planting had become small compared to the available supply and the utilization of the seed for other purposes was a minor matter, the disease was not thought of much consequence. The falling of leaves during the monsoon was by most people thought to be a natural phenomenon correlated with the wet conditions of a heavy monsoon. As, however, rubber yields did not go up so rapidly as was expected, this abnormal shedding of the leaves in the monsoon was investigated as a possible cause.

PERIODIC LEAF-FALL.

When young, *Hevea* does not shed its leaves periodically, so that up to the fourth or fifth year the trees are ever-green. Subsequently the normal season of leaf-fall on the West Coast is December to January. At some period during that time most of the trees are bare, but some retain a considerable proportion of the old leaves till the new flush is well expanded, and some trees are flushing while others are still shedding leaves. The leaves assume various tints of yellow, brown and red before they fall.

ABNORMAL LEAF-FALL.

A second and abnormal leaf-fall occurs on infected estates during the monsoon. Towards the end of June when the monsoon has set in steadily, trees begin to shed their leaves and continue to do so in ever-increasing numbers till about the middle of August or even later if the monsoon is late, after which leaf-shedding becomes inappreciable. Some trees lose all their leaves and stand quite bare but some lose only a portion. (Plate XVII, fig. 4.) Many, however, do not shed them to any appreciable extent, and these are invariably trees that have few or no fruits. By August the foliage looks decidedly thin and the ground is covered with a thick coating of fallen leaves. On the green leaf-surface there may be dull grey spots of

1 2 3

Fig. 1. On the left is a healthy branch, on the right a diseased one.
" 2. Leaf with spots on the surface and a spot on the petiole.
" 3. A young wilting shoot.

Fig. 4. A tree in the foreground that had shed most of its leaves by the 22nd of July.

Phytophthora Meadii on *Hevea brasiliensis*

round or somewhat irregular outline with minute drops of coagulated latex towards the interior. (Plate XVII, fig. 2.) The stalk of the leaf or of a leaflet may have a dark brown spot which in well marked cases is slightly sunk below the general level of the surface and has drops of coagulated latex. (Plate XVII, fig. 2.) Leaves sometimes assume shades of yellow and red before they fall as happ.ns during the normal leaf-fall in December-January, but quite a considerable number come down green with no discoloration on the leaf-surface or on the stalk. After this second leaf-fall a certain amount of new flush is produced, but badly attacked trees stand bare till the natural periodic renewal of leaves in January.

Some trees in the tropics shed their leaves normally several times during the year. Among others Schimper[1] mentions that, in the botanic gardens at Buitenzorg, *Urostigma glabellum*, a gigantic tree, sheds its leaves and produces new foliage about every two months. No records of this kind, so far as I am aware, have been published for trees in South India. There is, however, an impression that *Terminalia catappa*, to mention one only, sheds its leaves twice during the year. Mr. R. D. Anstead, to confirm this impression, kept a record last year in Bangalore and found that leaf-fall occurred in February and October and both periods of leaf-fall were followed immediately by the production of blossom. Trees that usually have only one period of leaf-fall, sometimes in dry seasons, have a second more or less complete leaf-fall. *Melia Azadiracta* in Coimbatore generally sheds its leaves once a year in March and flowers in April, but in 1918, a year of prolonged drought, it shed its leaves a second time in September and flowered about the end of that month. Though blossom often follows leaf-fall this is not always so; for example, in the case mentioned above by Schimper. In the case of the second leaf-fall of *Hevea* no period of flowering follows: it is not a general phenomenon over all estates but is confined to particular areas and varies in amount from year to year on the same block of trees. It does not occur in Burma and the Straits, and in Ceylon occurs as it does in India. It seems more likely to be due

[1] Schimper A. W. F. *Plant Geography*, Eng. Tran., 1903, page 245.

to a local influence affecting individual trees, than to an outward or an internal cause connected with periodicity in the leaf-fall. A fungus, *Phytophthora Meadii*, was found to be constantly associated with trees that had the second leaf-fall and was shown to be able to cause leaves to fall from shoots that it had invaded.

Besides occurring on leaves and causing them to fall, this *Phytophthora* also causes a fruit-rot, a rotting of the bark near the tapping cut, and a partial die-back of the branches.

Fruit-rot.

About three weeks after the monsoon rains have set in, dull ashy-grey spots appear on the fruits of infected trees and gradually increase in size till they cover the whole fruit. The outer pulp becomes soft and rotten. The " shell " does not split and the seeds become discoloured and rotten. (Plate XVII, fig. 1.) The surface of the spots, especially during a break in the rains, becomes covered with a thin incrustation which is white when dry and consists of mycelium of *Phytophthora* with a most copious formation of sporangia. In badly infected areas every fruit on a tree may be rotten and over whole blocks of trees it may hardly be possible to get more than a few sound fruits.

Die-back.

After the leaves have fallen from infected branches, the latter die-back from the tip to a greater or less extent, and at the junction of dead and living tissues the mycelium remains alive during the hot dry season from December to March when the fungus is not active on any part of the tree. When the early rains come, the fungus in this position invades new shoots that arise from the branch immediately behind and causes them to wilt. It gets on to the leaves and causes them to shrivel (Plate XVII, fig. 3), and forms on their surface many sporangia, the zoospores of which get to other shoots and leaves.

Bark-rot.

During the heaviest part of the monsoon when the trees are continuously wet, a rot appears in the vicinity of the tapping cut.

Dark spots appear and extend upwards on the recently tapped bark for an inch or two in dark streaks, the underlying tissue becoming soft and sodden, and exudations of latex appear on the surface as well as in cracks in the tissue, forming sometimes large pads between the bark and the wood. If no break occurs in the rains and if tapping is not stopped, the bark splits vertically along the lines down to the wood, then laterally, exposing the wood sometimes throughout the length of the tapping cut. The bark gradually rots away leaving an exposed area of wood sometimes 17 inches long by 1 to 4 inches broad. In some years when the rains are not so continuous and when tapping is stopped at once, bark-rot though present does not penetrate so far and the wounds heal over fairly quickly after the rains have stopped.

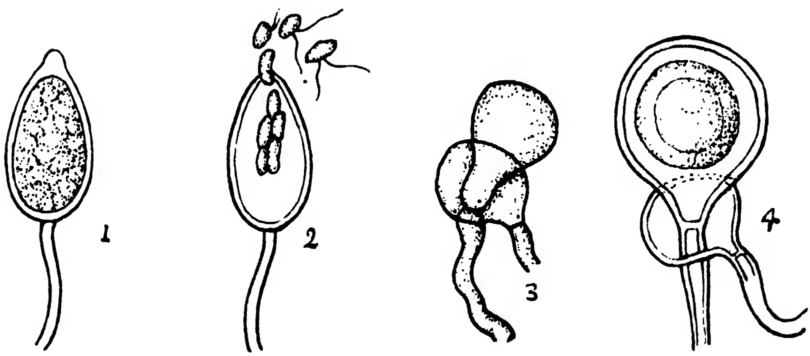
Second leaf-fall usually occurs first on *Hevea* when the trees come into the fruiting stage which in South India is usually about the fifth year. Then, however, it is the fruit-rot that is most in evidence, while in succeeding years the second leaf-fall becomes more noticeable. Younger *Hevea* does not have such a leaf-fall in the monsoon though it has been seen on individual trees or groups of trees where such have been planted among older trees or occur as supplies. Bark-rot may occur in the first season in which the fruit-rot appears or in a subsequent season, but it has not been seen on blocks that have not had fruit-rot. The disease began in the southern part of the *Hevea*-growing area and gradually extended till now few estates have escaped loss to some extent.

The fungus.

Phytophthora Meadii is found in all the tissues of the parts already mentioned. The hyphæ ramify chiefly between the cells and either come to the surface to produce their sporangia or produce sexual cells inside the tissue of the fruits.

The sporangia are minute pear-shaped sacks containing usually from 14 to 22 spores. When one is ripe, the apex dissolves in the presence of water leaving a hole through which the spores escape. Each has two cilia which lash to and fro and cause the spore to move in the drops of water. They are produced in enormous numbers,

especially on leaves and fruits. The sexual spores are particularly interesting for the fact that the oogonium (female element) grows through the antheridium (male element). They have thus the same relative positions as Pethybridge found in *Phytophthora*



1. Ripe sporangium. 2. Motile spores escaping. 3. Young antheridium and oogonium. 4. Mature antheridium, oogonium, and oospore.

erythroseptica on *Solanum tuberosum* (potato) and Dastur in *Phytophthora parasitica* on *Ricinus communis* (castor). The oospore is thick-walled and the protoplasmic contents are dense, and it has probably the rôle of a resting spore.

The fungus has been brought into culture on various media, *e.g.*, French-bean-agar and Quaker-oats-agar, and these cultures have been used with success to cause the various phenomena on leaves, branches, fruit and bark. Put on *Ricinus communis* (castor) and on *Manihot glaziovii* (Ceara rubber) the fungus attacks the leaves and stems though it has not been found on these two plants in Nature. Put on fruits of *Theobroma Cacao* (cocoa plant) it causes a fruit-rot somewhat like the fruit-rot caused by *Phytophthora Faberi* in countries where cacao is grown as an economic crop. Careful comparative tests were made with these two fungi on cacao and *Hevea* fruits, and it was found that *P. Faberi* and *P. Meadii* readily infected *Hevea* fruits while cacao fruits were readily infected by the former but with difficulty by the latter.

Dissemination.

The fungus appears to start its activity after the dry season at comparatively few points, but when the monsoon has once burst it

spreads rapidly. Sporangia are produced on the surface of the fruits in very large numbers indeed, and the zoospores in correspondingly greater numbers. The rapid dissemination from the first few infected fruits can be explained by rain-drops that fall on these infected fruits splashing the spores considerable distances to other fruits. Faulwetter[1] showed by experiment that water is splashed by a falling drop only when it falls upon a film of water, and it is the water of the film which composes the splash drops. A drop 0·2 millimetre falling 16 feet on to a horizontal glass slide covered with a film of water splashed drops to 24 inches. In wind driven by an electric fan and travelling at ten miles an hour at the point of splash which was three feet above the floor, a drop falling 16 feet splashed drops to extreme distance of 18 feet. The size of the drops is comparable to that of rain-drops and winds of ten miles an hour, and much more during the early part of the monsoon are often experienced on rubber estates. With the almost continuous rain the opportunity of continuous distribution by splashing is given, and even though frequent collisions between splash-drops and rain-drops will occur, thus preventing many of the former from reaching their extreme distance, still some of them will be carried off and be again splashed farther distances. This explanation would seem to be sufficient to account for the rapid spread of the fungus from fruit to fruit and to leaves on an estate, and the great number of motile spores produced on infected fruits provides many opportunities of their being washed down on the tapping surface.

Loss.

Hevea has been attacked by this fungus in South India before planting has been well established, so that there is no very extensive series of figures showing the yield of latex for any length of time on the estates of healthy trees. Estates have been in bearing for only a few years, 8 or 10 at the most, and that on a comparatively small acreage which has gradually become affected by abnormal leaf-fall. It is thus difficult to estimate the latex yields that might normally

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[1] Faulwetter, R. C. "Wind-blown Rain, a factor in Disease Dissemination." *Journ. Agric. Res.*, X, pp. 639–648, 1917.

be expected. That so far they have not come up to the expectation current at the time of planting is fairly generally conceded, and part of the shortage is undoubtedly due to the effects on the trees of *Phytophthora*. The loss due to the rotting of fruits is a minor factor, as the utilization of fruits for purposes other than planting, for the present at any rate, hardly comes into the estimate. From discussions with most of the planters who have had much to do with the disease, I have come to the conclusion that 30 to 40 lb. of made rubber per acre per annum is about the average loss and it may be as high as 70 or 80 on badly infected blocks of trees. This transposed into money value, with the rubber, say, at 2*s*. 9*d*. per pound and the cost of production, say, at 9 pence a pound, gives a loss of from £3 to £4 per acre per annum, which multiplied by the yielding infected area of about 30,000 acres represents a total loss to the industry of about £100,000 sterling and a possible future loss over the area of 60,000 acres of a very large sum of money indeed. The loss involved is so large that it is practicable to spend a large sum of money on preventive measures on every estate.

Preventive measures.

In considering preventive measures the main facts to be borne in mind are (1) that the mycelium passes the dry weather inside branches that have partially died back, (2) that oospores, which are resting spores, are found in the fruit, and (3) that the fruits are the main propagating centres for multiplying the fungus. This suggests that the branches that have died back and the fruits should be dealt with. In the one case the aim is to stop the fungus from beginning its activity in the new season, and in the other to stop its rapid propagation after it has once begun. If all branches that this fungus has caused to die back were removed, say, a foot beyond the junction of living and dead tissues, many of the centres of infection that begin the new attack of the fungus each year would be destroyed. Now all branches that die back on *Hevea* do not do so because of this fungus. There are other factors that produce die-back, *e.g.*, shade causes the lower branches to die and other fungi also do so. There is no simple field method of distinguishing between these various causes,

so that, if die-back branches are to be removed, then all will have to be removed irrespective of the causative agent. Many of the branches that have died back are mere twigs while others are larger. There are many such on each tree— far more than is realized till the necessity comes to remove them—and they are scattered over the tree indiscriminately ; however it is quite possible to remove them to a very large extent.

It has been shown that the fungus may invade a branch along the fruit-stalk, and that the fruit-stalks of rotted fruits may remain on the tree through the dry weather till the beginning of the monsoon. This is a real difficulty in the way of preventive measures, for it is impossible to remove every possible centre of infection of this kind. If all these old fruit-stalks were removed when the trees are bare in December-January, there is the fact that the mycelium of the fungus invades the branch from which the fruit-stalks spring at their point of insertion. Removing die-back branches would not destroy this source of re-infection entirely.

Removal of the fruits before the break of the monsoon would stop the rapid propagation of the fungus that begins about 15 days after the monsoon has set in. This would also for future infection get over the difficulty mentioned in last paragraph with regard to infection by fruit-stalks. If the fruits are not there to become infected the fruit-stalk would not carry the mycelium of the fungus into the branches.

There is another possibility, *i.e.*, the destruction of the flowers in order to prevent the formation of fruit. This could be done by cutting off the flowers or by spraying them with a chemical that would kill them. It has been found that only about 35 per cent. of the inflorescences bear mature fruit, that the stalk of the inflorescence is so pliable that it bends before the knife unless it has almost a razor edge, and that many leaves are removed with the inflorescences. These three drawbacks render this method impracticable. A solution of copper sulphate does kill the flowers, but spraying is impracticable because of the lack of water in the flowering season and, since the inflorescences are scattered over the whole tree, so much of the solution has to be used in order to get at each flower that it

practically means spraying the whole tree. The same applies in an increased degree to spraying the fruits in order to prevent the fungus developing on them as the stand of foliage is greater during the fruiting season.

The question whether it is not possible to prevent trees from flowering or to reduce the amount of flowering by some cultural means has also been considered, but it does not seem feasible. Horticultural endeavour has been rather in the direction of increasing the flowering capacity of plants, and so far as we know there are no cultural methods of preventing a tree from flowering or reducing the number of flowers it produces that are applicable in estate conditions.

In a block of 100 acres dead branches and fruits were removed during two successive seasons. An adjacent block of about the same size was taken as a check. In 1917 the contrast between the amount of second leaf-fall was very marked. While the check blocks had a heavy fall of leaves, the treated block had hardly any. One tree in the treated block, inadvertently omitted during the operations, shed nearly all its leaves and had fruit-rot, and an adjacent tree shed the leaves on the side next it. Bark-rot though present was very much less on the treated block. The operations were very carefully carried out and the total cost was Rs. 19-10 per acre. In 1918 the monsoon was scanty and the disease was not so severe as usual. Still the contrast was distinct and in favour of the treated block. In 1918, from another block of 70 acres the dead branches only were removed and the result was satisfactory. It requires a more normal monsoon, however, to decide whether this treatment alone is enough. If it is, it will be more economical as the removal of the branches costs about one-third of the total cost. The drawback of this method is that a large labour force is required at the time when the coolies usually go to their homes in the low country. If the method stands the test of further seasons, then its application becomes a matter of business organization.

Meantime efforts are being concentrated on the prevention of bark-rot. The method that has become most general is to paint with a chemical, usually one of the products of coal-tar distillation,

the tapped surface of the bark that is to renew. Izal and a mixture of tar and tallow are the two most employed though others are used according to availability. Greater attention is also being paid to getting a clearer air space around the trunks and to keeping the estate in a clean condition.

THE COFFEE PLANTING INDUSTRY IN SOUTHERN INDIA.

BY

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THE history of the introduction of the coffee plant into India has been given in an article already published in this Journal.[1]

Tradition has it that this crop was first introduced about two centuries ago by a Mahomedan pilgrim named Baba Budan, who planted it on the hills which bear his name in the Mysore State. The first systematic plantation in Mysore appears to have been established in 1830 near Chickmaglur, and about this time plantations were also established in the Wynaad and on the Shevaroy Hills. By 1846 it had spread to the Nilgiris. In Mysore the oldest existing coffee was planted between 1830 and 1841, while a number of estates were opened from 1870 to 1880.

For the following account of the early history of coffee in Coorg I am indebted to the kindness of the late Commissioner, Mr. F. Hannyngton.

"The suitability of the soil for coffee cultivation appears to have attracted the attention of the European planter about the year 1882. The capabilities of the province as a coffee-growing country had long before been known to the natives, and it is a matter of surprise that European enterprise did not enter on the field till a much later date. It is conjectured that, during the time of the Coorg Rajas, some Moplas, who had obtained grants of land near Nalknad introduced the shrub from seed which was brought from

[1] *The Agric. Journ. of India,* vol. XII, pt. III, p. 413.

'Mocha' or perhaps second-hand from Manjarabad. Its successful and profitable cultivation was at first concealed from the Coorgs, but these were shrewd enough to find out for themselves that, whilst none of the fabled fatal consequences followed the cultivation of the shrub, there was a ready and lucrative sale for the produce. Through the exertions of the first Superintendent, Captain Le Hardy (1834–1843), who took a deep interest in the material prosperity of the country, the coffee plant became almost universal.

"When coffee cultivation was taken in hand by European skill and energy the industry soon assumed greater importance. Mr. Fowler, the first European planter, opened up the Mercara estate in 1854, Mr. Mann became the pioneer on the Sampaji Ghat in 1855, Dr. Maxwell opened up the Periambadi Ghat estates in 1856, and in 1857 Mr. Kaundinya founded Anandapur village with a most promising plantation in the bamboo district. Round these first centres of cultivation, dozens of extensive estates gradually sprang up.

"The year 1883 marks the commencement of the decline of coffee, when the price fell by forty per cent., a result due chiefly to an over-stocked market and the competition of Brazil. The low prices fetched during the following few years dealt the death-blow to many Indian estates, the owners of which were dependent on loans from *sowcars* whose high rates of interest they were no longer able to pay; they were therefore unable to raise the funds to meet their working expenses and the estates rapidly deteriorated. A few years' neglect in a coffee estate is sufficient to ruin it, and the fall in prices therefore resulted in the disappearance of many once flourishing estates, nor could the exceptionally high prices subsequently obtained avail to redeem the misfortunes of the past. The estates on the Ghats which were opened without shade were now beginning to show signs of irretrievable decline; in 1889 several large European estates on the Sampaji Ghat were relinquished wholly or partially, and a few years afterwards the estates on the Periambadi Ghat were resigned to Government. By 1898 all coffee on the Ghats had practically disappeared."

Another factor which played a part in the reduction of the acreage under coffee was disease, especially leaf disease, caused by the

fungus *Hemileia vastatrix*, and root diseases. The latter are associated with the decaying stumps of jungle and other trees. As the coffee began to decline and leaf disease to appear, many planters thought that they were growing the wrong kind of shade and proceeded to change it by cutting out large numbers of certain kinds of trees, especially *Acrocarpus fraxinifolius*, without taking any precautions whatever about the stumps, which, as they rotted, afforded a suitable habitat to root-disease-producing fungi. These rapidly spread to the coffee and killed large areas of it, and in some parts of Mysore one now sees tracts of land returned to grass and scrub which were once flourishing coffee estates.

There is, however, a more cheerful side to the picture ; many of the best estates weathered the storm and with the improving situation the area of these was increased. The total distribution of the coffee acreage in South India at the present time is as follows :—

	Acres
Madras Presidency ...	48,441
Coorg ...	42,654
Mysore State ...	122,500
Travancore State ...	7,000
Cochin State ...	2,500
Total ...	223,095

As will be seen, the chief coffee-growing areas are Mysore and Coorg which contain 74 per cent. of the total. In these districts the acreage is approximately divided as follows:—

COORG.

	Acres
Area under cultivation by Indians on European lines ...	17,809
Area under cultivation by Indians on native lines ...	3,625
Area under cultivation by Europeans ...	21,220

MYSORE.

Area under cultivation by Indians ...	101,255
Area under cultivation by Europeans ...	21,245

During the last 15–20 years much more attention has been paid to the scientific cultivation of coffee under the guidance of Dr. Lehmann and others, and with the establishment of the Scientific Department of the United Planters' Association of Southern India in 1909, the control of diseases and systematic manurial schemes have been widely adopted. Much remains still to be done and learned, but some of the more marked advances may be mentioned.

The study of the mechanical and chemical composition of the coffee soils in relation to the manures required has received attention. South Indian coffee soils are markedly deficient in calcium oxide and available phosphoric acid. The shade, under which the coffee must be grown to protect it from the sun and drying winds in the hot weather, produces conditions rapidly leading to acidity of the soil. The falling leaves make a valuable mulch covering the ground several inches deep, and as this rots down acidity may be set up. Consequently frequent applications of lime are found to be beneficial, the controlling factor being the cost of this treatment. Unfortunately, there are few coffee estates situated near good deposits of limestone and most of this material has to be transported from the coast in the form of burnt shells, and this is expensive. In Coorg, trials are now being made of finely crushed limestone obtained in Hunsur some thirty miles away. Applications of soluble and basic phosphatic manures like basic superphosphate and basic slag have also proved beneficial. For many years it was the custom to apply to the coffee nothing but a mixture of roughly crushed bones and poonac locally obtained with an occasional dressing of fish manure, but now the benefit of varying the manures applied and supplementing them with occasional applications of potash has been realized. A growing number of estates take scientific advice as to manurial programmes based on soil analyses and use a variety of fertilizers, and such systems have proved their value over and over again in increased crop.

Diseases can also be controlled. Root diseases which have done so much damage in the past, are now recognized by planters as due to the attacks of specific fungi, and precautions are taken to deal with them as soon as they occur. The general sanitation of the estates has been improved and stumps of jungle and felled shade trees are removed or isolated. The lines of advance lie in the direction of a careful study of the life-history of the fungi causing these diseases and their exact relation to the decaying stumps of certain trees. Were all the latter known, steps might be taken to mark down their occurrence in new clearings and remove them. In the Nilgiris, for instance, new land is nearly always occupied by

secondary jungle and a very common constituent of this is a small tree, *Symplocos spicata*, the decaying roots of which always induce root disease of both tea and coffee, and it has been found profitable to clear the land of the roots and stumps of this tree before planting.

Two important fungi attack the leaves of the coffee, *Hemileia vastatrix* and *Corticium Koleroga*, popularly known as leaf disease and black rot, respectively. The former is wide-spread and found on coffee all over the world, and it is credited with having killed the coffee industry in Ceylon. These diseases can be controlled by spraying the coffee at the right time with Bordeaux mixture or Bordorite, and a good deal of work has been done of late years in this direction. The limiting factors are water and labour. Black rot only occurs on limited areas and thus is comparatively easy to control by spraying, but to control leaf disease successfully very large areas have to be sprayed at one time, and this is a difficult problem. In Nairobi, however, the coffee estates are sprayed throughout two or three times a year, and there is little doubt that the time will come when the South Indian planter will wake up to the fact that spraying is a practical and paying proposition, and power sprayers will be introduced.

Of insect pests one of the most important and deadly is a scale insect, *Coccus viridis*, and a variety of it, *Coccus colemani*. This scale attacked the coffee on the Nilgiris many years ago and nothing was done to check it with the result that it spread to the shade trees, weeds, and general vegetation, and in some districts has killed out the coffee and rendered its cultivation unprofitable. Luckily in this part of India coffee could be replaced by tea. In Mysore and Coorg, however, coffee is difficult to replace by any other crop, and when the scale appeared in these districts in 1913 something like a panic occurred. It was found, however, that the scale could be controlled by prompt spraying with an insecticide, like fish oil resin soap, while in the monsoon it was attacked and naturally controlled by two fungi, *Cephalosporium lecanii* and *Empusa lecanii* which also works in the cold weather. Steps were taken to teach the planter the best methods of control, spraying in the dry weather, and spreading the fungus by contact, that is, by introducing branches

containing fungus-attacked scales and tying them into the trees where the fungus did not occur naturally, in the wet weather, and the pest has been successfully kept in bounds, and it now does only local damage in years which particularly favour it. It was also found that certain species of ants common on coffee estates, more especially *Cremastogaster*, play a large part in the distribution of the scale, and if their nests are energetically destroyed the attack can be largely controlled.

In Coorg, another insect pest which does a considerable amount of damage is a scale insect, *Dactylopius citri*, which attacks the roots of the coffee, especially young plants. So bad is this pest in places that it was found impossible to raise young clearings. Lefroy first studied this pest and recommended certain measures for its control. Recently a cure has been found in apterite, a soil-disinfectant used in England, consisting of naphthalene and crude carbolic acid. This has been used with great success to protect the young plants till they get big enough to resist the attack of the scale. Since the war it has been impossible to import this material and stocks were soon exhausted. It is now being manufactured in the Madras Presidency, and after the war it is possible that it will be found cheaper to make it than import it.

Other pests and diseases have been controlled, and at the present time the coffee planters are fully alive to their importance and understand their causes. Much remains still to be done, however, in the study of the life-history of diseases, especially those caused by fungi, but a considerable advance has been made.

The coffee on many of the estates is very old, in some cases individual trees must exist that are 60–70 years old whilst on estates like Balmadies, in the Shevaroy Hills, some of the coffee is over 90 years of age. The time is coming when this old coffee will have to be replaced. During the history of the coffee industry one big change has already taken place, when the old "Chick" coffee was replaced wholesale with the more vigorous and robust Coorg strain. There seems to have been little difficulty in making this change but on the old estates now it is not easy to raise young plants or to grow supplies, and old coffee land is notoriously difficult

to replant. This is due to a number of causes which need not be gone into here. One of the reasons for failure, however, is that the strain of coffee now grown has been allowed to deteriorate. No care has been taken in selecting seed from which to raise nurseries. One of the most important advances in recent years has been the realization of the necessity for better seed selection, and the possibility of raising a new, vigorous strain of coffee by means of hybridization along Mendelian lines. This subject has been dealt with in an article reproduced in another part of this Journal. The matter has been taken up by a few of the more farseeing planters, and a hybrid exists which has all the vigour of the old Coorg, is highly disease-resistant, and which bears very heavily, much more heavily than the ordinary *arabica* type now cultivated on the estates in general. This is now being grown on an estate scale and a great future lies before it. In fact the future of coffee in South India undoubtedly lies in two main directions, first the raising of good hybrid strains which will bear more heavily than the present coffee and the replacement of the old worn-out estates with these and, secondly, in a combination or co-operative society of coffee planters to control the local coffee markets and prices and to develop and organize the local sales of Indian-grown coffee, as well as to do their own curing. Progress is slow and it is difficult to overcome deep-rooted customs and prejudices, but there are ample signs of a new era in this direction.

By far the majority of the coffee grown in South India is of the *arabica* variety. Of recent years a certain amount of *robusta* coffee has been planted; and this variety is in growing favour on poor soils and as a catch-crop among *Hevea* rubber. It bears heavily but produces an inferior grade of bean, but it will no doubt find a place as a subsidiary crop in many places.

Recent advances have also been made in the machinery employed on the estates to prepare the coffee for market. In old days bullock power was used for driving the pulper, now the majority of estates are equipped with oil engines and modern pulpers and well-laid-out arrangements for washing the coffee. On one estate a further advance has been made in the instalment of a dryer in

which the washed parchment coffee is dried by means of hot air in a revolving drum. This hastens the process as compared with the usual sun-drying and renders the process independent of weather. Moreover, it improves the colour of the coffee and results in a great saving of labour. The final curing of the coffee is done by curing firms at the coast where a hot sun is available. Here again there is room for improvement, and development lies along the line of co-operative bodies of coffee planters owning their own curing works to which the coffee will be sent from the estates comparatively dry from artificial dryers. In this way the curing of the crop will be hastened and shipment take place well ahead of the monsoon.

With regard to the future development of the coffee industry, several lines have already been indicated. It remains to say that the Scientific Department of the United Planters' Association of Southern India is about to be reorganized and enlarged. It will be controlled by the Madras Agricultural Department under the Director of Agriculture. A coffee experiment station is being established in Coorg on the lines of a Government farm, where a whole series of experiments will be undertaken to study manuring problems, cultivation methods and disease control, and possibly in the future plant-breeding problems. It is also proposed to add to the staff a Planting Mycologist recruited from Europe who will take up among other things the study of the many fungi which attack coffee.

There are a certain number of people who have never happened to visit a good coffee-growing district, who are apt to think that coffee planting is a decadent industry, but this is by no means the case. It is a very flourishing concern and its outlook on the future is a bright one. The demand for high grade coffee in the European market is always likely to exist, and it is just these high grade marks which South India is able to produce and has always produced.

THE "RAJAH" PLOUGH.

BY

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ON a bright morning, nearly eight years ago, the dry coarse grass on land that now forms part of the Peshawar Agricultural Station was set alight, and before nightfall, with a following breeze, a large part of a block of fifty acres was black in ashes. The jungle consisted chiefly of "dáb" (*Eragrostis cynosuroides*) with some "kahai" (*Saccharum spontaneum*). After irrigation the "Rajah" ploughs were set to work, a plough following in the furrow of each land-plough to ensure tillage to a depth of nine inches. In the following *kharif*, hardly a blade of the grasses appeared; in one brief cold season the "Rajah" completely extirpated the coarsest of root grasses from red loam. The oxen were ordinary animals, the average price of them being Rs. 92-8. And now, after eight years' constant toil with western ploughs, harrows, rollers, cane-mills, etc., most of these good oxen are still in regular work and "going strong," and the "Rajah" ploughs that first turned over the area of 200 acres are still in daily use and sound as when they were purchased in 1910. Without the assistance of the inverting plough the Agricultural Station might still be striving to get rid of tough root grasses. Men and bullocks alike adopted the "Rajah" easily. Almost from the outset they ploughed lands 220 yards long in a manner that would be no discredit to English craftsmen. Hardly ever has the writer seen a Tarnab ploughman leave the stilts to goad his oxen. Plate XVIII, fig. 1 shows that this is unnecessary if the ploughman is provided with a very light, thin, solid bamboo goad, which may rest on the hake of the plough or remain lightly balanced in the hands of the man. Should a ploughman be observed

Fig. 1 The "Rajah" Plough.

Fig. 2. Convenient method of carrying the "Rajah"

following on the land without some special reason for doing so, he is liable to be fined at Tarnab, but it has not been necessary to impose a penalty during the past four years. His acre done, the man may unyoke and go home. In many operations besides ploughing, the "Rajah" has proved most useful on the farm. It sets up "bunds" on irrigated land; it is employed to make roads and to ensure camber on these; it is sometimes used in earthing up crops, it does most of the work in cutting out watercourses. This all appears satisfactory. The plough, the oxen, the man combine to turn out real good work *on the farm*. It might therefore be expected that the "Rajah" would be appreciated and in daily use by many cultivators, at least in the Peshawar District. But this is not the case. There is not a "Rajah" or other mould-board plough regularly and profitably employed on any cultivator's land in the North-West Frontier Province. And at once it may be stated that it is not the cost of the implement that stands in the way of its adoption by the cultivators. A small unsymmetrical irrigated field can rarely be economically treated by a mould-board plough. With this implement it would not be altogether easy for an English ploughman to leave the land in a level state fit for irrigation. And chiefly for this reason it is feared that for many years to come there is little hope of the cultivators using inverting ploughs on irrigated land in the North-West Frontier Province. After long years of careful dressing, the cultivators' fields are level as level can be. The country plough does not upset the land level; a mould-board plough always does so more or less, and irrigated crops are invariably poor where the land is not level. On unirrigated areas the mould-board plough may sometimes be profitably employed, yet on these lands deep ploughing is usually less necessary than on irrigated fields where rank weeds and grasses are so liable to spring up, and perfect soil-aeration must be assured.

It is on foul, neglected land that the "Rajah" best demonstrates its value to the cultivators, and when an implement is purchased it is usually intended to clean old or to break new land. Those few keen Pathan farmers who have tried the "Rajah" and have sent their ploughmen to Tarnab to be trained in using it, have

soon set the steel implement aside and returned to the plough of their fathers. Knowing this to be the case no improved western implement is sent out from the station until the intending purchaser has demonstrated his ability to use it in a workman-like manner.

There is of course no doubt whatever that the inverting plough tills the land far better than, and perhaps just as cheaply as, the country implement. But in the North-West Frontier Province the time has not yet come when even the "Rajah," which has been found so useful at the Agricultural Station, may be generally recommended to the cultivators of small areas. On clean land that has been regularly tilled the country plough is fairly efficient; it does much more than "scratch the soil." Skilfully used, it produces an excellent tilth of moderate depth.

It is sometimes difficult to find, and it is always troublesome and expensive to maintain, numerous yokes of good oxen, and it is just possible that the owners of broad acres may favour light motor-tractor cultivators rather than small mould-board ploughs drawn by bullocks, when they decide to farm part of their land, instead of parcelling it all out to cultivators who have very little capital.

Plate XVIII, fig. 2 shows a good pair of Awankari bullocks taking the "Rajah" to the field in a convenient manner which does not appear to be commonly employed where mould-board ploughs are used.

After this article was written, the writer invited an Indian who has had much experience in using the "Rajah" to say what he thought of the plough's work. "Excuse me, sir, but I hate it," was his reply. Then he explained how the implement kept him in a state of constant anxiety about the land levels. How, in order to make quite sure that the soil could be reduced to mellow tilth when he desired that, it was imperative to roll and level land ploughed by the "Rajah" positively on the day after the furrows were turned. He mentioned how this was frequently impossible and very often difficult and even undesirable, and that in these circumstances the furrowed land could not be levelled until it received rainfall. On the other hand, he held, even when the country plough leaves the land very very "cloddy," the level is not upset, and irrigation and tillage can be done at will.

IRRIGATION TANKS IN THE DISTRICT OF BURDWAN.

BY

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If the number of irrigation tanks in a tract is any guide to its agricultural prosperity, then the district of Burdwan, especially the central part of it, may be considered to have been, at one time, one of the richest portions of the province of Bengal. Nowhere else can so many tanks be found, scattered here and there all over the fields, throughout the length and breadth of the province. That this district used to be called the granary of West Bengal was due to the fact that the ryots were then fairly independent of the vagaries of the monsoon owing to the use of tanks. These tanks seem to have been dug long ago, and each of them was meant to command an area in proportion to its holding capacity—generally of about ten to twenty acres each—but unfortunately they have been long neglected and allowed to go into disrepair. Many of them have silted up to such an extent as to have been turned into actual paddy-fields, while others do not hold water enough for two or three acres in times of need. Mr. A. C. Sen in his report on the agriculture in the district of Burdwan says : "The great want of the Burdwan District, especially of its western and central parts, is a proper supply of water for irrigation purposes. The rainfall being often deficient in total amount, or irregular in distribution, artificial irrigation is necessary for almost all important crops except pulses and barley. In fact, the cultivation of surgarcane, potato, and other important crops can only be undertaken in places where water is available. * * * * * * * * * * *. In no

other part of Bengal are so many tanks to be found, but almost without exception they have been long neglected and are now overgrown with weeds and filled up with silt."

In consequence, the present economic condition of the ryots of the district—at least the central part of it which is mainly agricultural with no other industry to speak of—is far from being satisfactory. They are now quite dependent on the distribution of rainfall for their paddy, which is by far the most important harvest of the year in the locality. The cultivation of potato, sugarcane and other profitable cold weather and hot weather crops is now limited to very small areas for want of water-supply. Sugarcane was an important crop in this tract, but now the area under it is going down year by year in spite of the introduction of the superior iron mill and of the rise in the price of *gur*. The cultivation of sugarcane entails much care and labour, and if it fails, or a satisfactory crop is not obtained simply for want of water, the ryots can hardly be blamed for giving it up. Leaving the more profitable crops alone, even when one comes to consider the cultivation of paddy—the mainstay of the cultivator—he sees that the result is largely a matter of chance. Being dependent on rainfall, the ryots try to transplant as large an area as they can within as short a time as possible on the first decided break of the monsoon without having any regard to good tillage ; and they leave the rest to the mercy of the season. If the season is good, they reap a fair harvest and thank their stars. But if the rainfall is scanty, every ryot tries to procure the very little water that can accumulate in these tanks for his own crop, and this leads to bitter quarrels and riots ending in criminal cases in the courts, loss of money and sometimes even imprisonment.

Moreover, this method of cultivation, apart from bringing in its train the effects of bad tillage—and it is well known how serious these effects are—gives rise to another economic evil, namely, breaking up of pasture lands. Under the present state of things, intensive methods of cultivation are out of the question, and extensive cultivation, requiring more land with the increase in population, naturally tempts the ryots to encroach upon pasture lands. So this, among other factors, is largely responsible for the serious

shortage of pasture lands and consequent deterioration of cattle in the district. The writer has heard people lamenting that cows do not now give half as much milk as they used to thirty years ago. The reason is not far to seek. Indeed every distress and difficulty of the ryots can be traced back to general poverty, and the writer believes, along with many old ryots of his village, that their poverty can be traced to the long neglected and deplorable condition of the irrigation tanks.

Agriculture cannot prosper in a tract where there is no source of artificial irrigation, as it is absolutely necessary to supplement the rainfall, which is often irregular in distribution, in order to raise a satisfactory crop. The Government of India in their resolution on Land Revenue Policy in the year 1902 remarked—" When the produce of the land is liable to great and frequent fluctuations, owing to failure of irrigation or vicissitudes of season, there is reason to apprehend that a fixed assessment may ruin people before it teaches them." But here is a tract where the ryots have become entirely dependent on the vagaries of the season, where they are being reduced, day by day, to the verge of utter destitution; yet they have to pay a fixed rent. The Government are unwilling to interfere because of the Permanent Settlement of Bengal, which has transferred the absolute right in the lands from the State to the hands of the zemindars of Bengal.

These tanks were excavated by zemindars long before the Permanent Settlement, when they had an interest in the lands, as the rent was then a certain portion of the produce—usually payable in kind—and it was an economic loss to them if the cultivators failed to get a full crop out of their lands. Besides, land was then more than sufficient for the population, and the zemindars had some difficulty in disposing of their lands, and as nobody would willingly cultivate lands which had no facility for artificial irrigation, they excavated and used to maintain these tanks. But under the Permanent Settlement the zemindars have practically no concern with their lands; whether the cultivator gets a full crop or not the zeminder gets his rent. So the zemindar takes no interest in the improvement of his lands or in the amelioration of the condition of

the ryots. Moreover the real zemindar is now out of touch with the ryots owing to the presence of a series of middlemen—Pattanidars, Dar-pattanidars, Se-pattanidars, etc.—who have very little sympathy for the occupiers. A quotation from the Gazetteer of the district will show how clearly the state of affairs was understood by a high Government official: "The landlords and intermediate tenure-holders have become mere annuitants upon the land, taking but little interest in their nominal estates beyond ensuring the payment of their rent, and practically indifferent to their improvement, or to the condition of the cultivators from whom their income is drawn. Embankments, drainage channels, tanks for irrigation or water-supply, and other works of public utility constructed by the generosity of former landlords, are allowed to fall into disrepair; it is no one's business to repair them: and the landlords have no incitement to undertake any fresh work of improvement, as they can hope for no pecuniary benefit from it." But the zemindars seem to forget that the same Permanent Settlement that bestowed on them an absolute right in their property expected "that the proprietors of land, sensible of the benefits conferred upon them by the public assessment being fixed for ever, would exert themselves in the cultivation of their lands, under the certainty that they will enjoy the fruits of their own good management and industry, and that no demand will ever be made upon them, or their heirs or successors, by the present or any future Government for an augmentation of the public assessment, in consequence of the improvement of their respective estates" (Art. VI, Reg. 1 of 1793). It is needless to say that, as a rule, these hopes have been falsified.

Now the question may naturally arise why the cultivators do not look after the tanks wherein their vital interest lies? But the fact is that, whereas each tank was meant to command a certain area which was originally leased out to one or two persons, the tank forming a part of the holding (*jama*) or holdings, portions of holdings are always being transferred from hand to hand without reference to the rights in the tanks. At present it is not unusual to find that a tank may belong to a person who may have very little land within its influence; and holdings have been so much divided and

subdivided that it is not at all impossible to find fifteen or twenty or more persons having land within the area commanded by a single tank. Now under the present state of things the members of a village community are so poor and so divided into factions that it is extremely hard to get anything done by them. The owners of the lands say why should they go to renovate a tank which belongs to others. And the owners of the tanks say why should they go to renovate a tank the benefit of which would be enjoyed by others. These persons can hardly be expected to co-operate, and even if they were to agree, they cannot do anything for want of capital. A person who is in debt cannot possibly invest money on such works. So there is very little chance of the tanks being renovated by the cultivators unless some system can be devised. But if things are allowed to go on as they are, the tanks will be beyond renovation in the near future, and the agriculture of the locality will suffer an irrevocable loss in consequence.

The writer has been anxiously thinking over the matter for some time, and he has come to the conclusion, after discussing the matter with some of his fellow villagers, that the tanks can be renovated by the cultivators themselves if a scheme, the barest outlines of which are given below, can be framed and worked :

(*a*) Arrangements should be made so that each tank may belong to the different ryots in proportion to the amount of land they hold within the jurisdiction of the tank ; that is, the different ryots should have an interest in the tanks proportionate with their holdings. To achieve this, compulsion may be necessary on both the parties—sellers as well as purchasers.

(*b*) The right in the tanks should be automatically transferred with the transfer of land.

(*c*) The owners of the lands commanded by each of the tanks may combine to form a co-operative credit society ; so there may be as many societies as there are tanks. And tanks should be renovated from loans taken by these societies.

(*d*) Loans should be given by central co-operative banks or the District Board on their usual terms of business.

(*e*) Two or three tanks should be taken up for renovation every year in every village.

(*f*) Some form of expert supervision should be provided by Government to see that the work is being done properly.

THE FIRST SECTIONAL MEETING OF VETERINARY OFFICERS IN INDIA.

The First Meeting of Veterinary Officers was held in the Veterinary College at Lahore, from the 24th to 26th March, 1919, under the presidency of Mr. J. Mackenna, C.I.E., I.C.S., Agricultural Adviser to the Government of India. Besides representatives from the Veterinary Departments in the different provinces, the Directors of Agriculture, Punjab and the Central Provinces, the Director and the Second Bacteriologist, Imperial Bacteriological Laboratory, Muktesar, the Imperial Pathological Entomologist, the Offg. Imperial Agriculturist, and a representative of the Army Veterinary Corps in the person of Lieut.-Col. W. B. Edwards attended the meeting. Mr. A. W. Shilston, Second Bacteriologist, Muktesar, acted as Secretary.

The proceedings were opened by Mr. Mackenna in a short speech in which he referred to the excellent work done by the Veterinary Service in the great European war, dwelt on the necessity of a large and an early expansion of the Civil Veterinary Department, and eulogized the services of Col. H. T. Pease, Principal, Veterinary College, Punjab, who was on the eve of retirement from service. In order to ensure a regular progress, especially in research, he thought that it would probably be found desirable to have in India a strong Central Board of Agriculture, organized somewhat on the basis of the Board of Agriculture and Fisheries in England, or of the Boards of Agriculture in Scotland and Ireland, and that, if such a policy was accepted, veterinary science would no doubt be represented.

The agenda of the meeting comprised 12 subjects. An interesting discussion followed the introduction of the subject of veterinary education by Col. G. K. Walker, and a sub-committee under

the chairmanship of Lieut.-Col. A. Smith, Principal, Bengal Veterinary College, was appointed to deal with the question. The sub-committee considered that the small number of recruits annually required for the imperial branch of the department would not justify the very large outlay necessary to establish an efficiently equipped college for the provision of higher veterinary education in India as recommended by the Public Services Commission, and they, therefore, suggested that in order to assist Indians to qualify for the imperial branch of the service, selected youths should be sent to Europe by the aid of State scholarships. As regards the education required for the different grades in the provincial services, they recommended that this should be provided at the existing veterinary colleges, all candidates going through the same curricula with post-graduate courses for the higher grades : that the educational qualifications for entrance to the colleges should be raised : that the prospects of veterinary graduates should be improved : that the course of instruction should be extended over four years instead of three as at present : that the curriculum should be on the lines prescribed for the Royal College of Veterinary Surgeons and that a detailed syllabus should be prepared by the principals of the Indian colleges for final consideration at the next veterinary conference. The report of the sub-committee was adopted, and it was resolved that the meeting of the principals of the colleges to revise the curricula should be held in Calcutta.

The advantages and disadvantages of stationary and itinerating veterinary dispensaries, and the possibility of combining the two systems advantageously, were then considered. A discussion on the subject disclosed the fact that the conditions in the various provinces required different methods, and that it was necessary to adopt those found most suitable in each case. However, the conference was of opinion that the importance of establishing veterinary dispensaries with a staff adequate to deal with outbreaks away from headquarters should be impressed on Local Governments and on District Boards.

As regards the revival of the "Journal of Tropical Veterinary Science," which was abolished in 1912, it was, in view of the depleted

staff of the department, not considered expedient or feasible to raise the question at present.

In opening the discussion on the necessity for reorganization of the Indian Civil Veterinary Department, Col. G. K. Walker first gave a brief history of the department, in which he showed how its development was marked by vicissitudes, what its legitimate duties were, and how handicapped it was in performing those duties. He then advanced arguments to show that, if the department was to continue to do good work and to progress, a thorough reorganization was necessary. The conference passed the following resolutions on the subject :—

(*a*) "That this conference is of the opinion that the present constitution and organization of the Civil Veterinary Department is utterly inadequate to cope with the work demanded of it, and they, therefore, respectfully represent to the Government of India the absolute necessity of filling up all existing vacancies in the Indian Civil Veterinary Department without delay, and would emphasize the importance of a large expansion of all provincial departments to deal with the ordinary veterinary work of the country."

(*b*) "That the department should be placed in a position to deal with the diseases of animals, veterinary instruction, and all operations for improving the breeds of horses and agricultural stock in India."

(*c*) "That the Government of India should be asked to include in the List of Officers of the Civil Veterinary Department, the names of all officers of provincial cadre, classified under separate provinces."

(*d*) "That a central authority in the person of a Director-General is required to initiate and co-ordinate the work. He should be a specially selected officer with experience in each branch, if possible, and he should be given some measure of authority over the officers of the department."

Sub-committees appointed to deal with a part of the question reported on the strength and constitution of the imperial and provincial branches necessary to carry out the duties of the department, and recommended a revised nomenclature of the posts in it.

The next question discussed was—what concerted action can be taken to deal with surra and dourine. Col. Farmer said that the spread of irrigation had led to an expansion of surra in areas where the disease had not previously occurred, and that the practice of keeping horses in the stable between 7 A.M. and 7 P.M. gave very satisfactory results. It was pointed out that there was a constant risk of the introduction of the disease from Indian States where the Glanders and Farcy Act could not be applied. Regarding the treatment of surra, several members referred to having obtained promising results, though on a limited scale, and all emphasized the urgent necessity for further experimental research in this direction. As regards dourine, the diagnosis of which was frequently difficult, the conference was of the opinion that the provisions of the Dourine Act should be so modified as to make diagnosis on clinical symptoms fall within its cognizance.

In dealing with the question of applicability of the different methods of inoculation against rinderpest to conditions in India, the conference resolved, that when an adequate and sufficiently trained staff was available, the question of adopting the simultaneous method of inoculation more generally might be taken up as being more economical and more effective.

Several officers expressed their views as to the prevalence of bovine tuberculosis in the various provinces, and referred to the unsatisfactory results following the subcutaneous injection of tuberculin in India, upon which, Mr. Sheather suggested the application of the ophthalmic test. The conference emphasized the urgent need for investigation of the whole question of tuberculosis in India.

In connection with the question of the control of rabies in India, the conference considered that any suitable measure that could be adopted for reducing and destroying the surplus population of dogs was desirable, but that it did not appear to be possible, under the conditions prevailing in India, to deal more effectively with the disease. Power should, however, be given to veterinary practitioners to order the detention and destruction of dogs suffering from rabies.

The need for research had been strongly emphasized throughout the discussions of the conference, and when the question as to the method by which it should be brought about came up for consideration, the conference passed the following resolutions :

(*a*) "That in order to deal with the physiological problems of animal husbandry in India, it is necessary to have a fully equipped Central Research Institute with an adequate staff. The Muktesar and Bareilly laboratories, if the necessary staff is supplied, might be developed into a Central Institute of the kind proposed. In view, however, of climatic and other considerations, it may be necessary to consider alternative sites. The staff should be sufficient to permit of the deputation of officers to work out problems in collaboration with provincial veterinary officers either at provincial laboratories or in the field."

(*b*) "That the conference is in favour of the creation of a separate organization for the study of the insect parasites of men and animals, the connection with the Civil Veterinary Department being on the lines suggested by Mr. Howlett in his note."

With regard to the question as to whether, in view of the sectional meeting of veterinary officers, it will be necessary for them to attend the full meetings of the Board of Agriculture in India, the conference considered that it should be left to the Agricultural Adviser to determine whether veterinary officers should, in consideration of subjects coming up for discussion, be invited to the meetings or not. In this connection it was recommended that, for the present, meetings of veterinary officers should be held annually, and that all members of the Civil Veterinary Department should be invited to future meetings.

The conference was of opinion that some form of legislation was necessary to deal with cattle diseases, especially as regards segregation and the movements of cattle, and that such legislation should be introduced when possible.

In dealing with the question of the animal industry in India, the conference was of opinion that, except in special cases where rapid milk production was required, and where efficient control was established, the general importation of exotic breeds of cattle

should not be recommended at present, and that the main policy should be the improvement of indigenous breeds by selection.

The conference, from the veterinary point of view, was very successful and valuable. A detailed report of the proceedings is in the press and will be issued in due course.

VETERINARY RESEARCH: SOME RECENT CONTRIBUTIONS.

BELIN, M.—THE TREATMENT OF EQUINE LYMPHANGITIS BY PYOTHERAPY. *Receuil de Méd. Vét.*, 1919, Vol. XCV, No. 4.

The author describes a new technique for the preparation of the vaccine.

The pus is collected in a sterile flask. One part by volume (presumably an equal amount) of ether is added and the flask is shaken until the pus is broken down as much as possible. To this are added six "parts" (presumably six times the amount) of a solution containing 0·1 per cent. iodine and 0·4 per cent. potassium iodide in distilled water. This is added in two or three parts.

It is advisable to filter through several layers of sterile gauze. The vaccine can be used half an hour after preparation. (It may be pointed out that the description of the technique in the original leaves much to be desired.)

In practice the author has mixed together pus from numbers of cases of cryptococcic and bacterial lymphangitis for the preparation of his vaccine.

In the case of cryptococcic lymphangitis the author is in favour of giving a series of injections instead of the method advocated by Velu of giving single injections during the negative phase of the disease. He finds it more practicable when large numbers of cases have to be treated daily.

In the bacillary lymphangitis cases, the author has readopted his original method of giving an initial series of four injections followed by an injection every five or six days until recovery is complete.

The production of abscesses at the seat of inoculation is not, in the author's view, due to a ferment action as suggested by Velu, but to a special sensibility of certain animals to dead or attenuated bacteria in general and to cryptococci in particular.

It appears to be immaterial by what path the vaccine is introduced. In the case of intravenous injections there is the advantage that no local lesion results. In this connection it may be noted that the author has had two animals die while under treatment. In one case death was considered to be due to ante-mortem intracardiac clotting of the blood, and in the other, to endocarditis. It is suggested that in both cases death was a matter of coincidence.

In the author's opinion it is advisable to give a dose of 2 c.c. daily for six or seven days. From twelve to fifteen days after the last dose, provided the lesions fail to disappear or fresh abscesses are formed, a second series of injections of 2·5 c.c. of "sterilized pus" is given. (By using the expression sterilized pus it is not clear whether the author means his vaccine or not, and it may be pointed out that in view of the dilution of the pus in making the vaccine this is a point of some importance.)

The author briefly describes a number of cases in which the vaccine has been used in chronic cases of the disease, and draws the conclusion that the vaccine is actually responsible for the cures in these cases, and that the view that recovery has been spontaneous is mistaken.

VELU, H.—AN UNDESCRIBED DISEASE OF THE DOG IN MOROCCO. *Bull. Soc. Path. Exot.*, 1919, Vol. XII, No. 3.

In this paper the author describes an acute disease of the dog characterized by marked nervous, pulmonary and digestive symptoms.

From references given, it would appear that the disease has been observed in other parts also. Heckenroth describes it as occurring in Senegal, and Labouisse in Mogador.

The disease broke out at some distance from Casablanca in August, 1918, and within a couple of months, the majority of the dogs in neighbouring districts had died. A few isolated cases were observed in Casablanca itself.

Nervous symptoms always predominated, and presented a picture which suggested the possibility that the disease was in reality rabies.

From the outset, the cases were marked by inco-ordination of movement and slight paralysis. In many cases the animals stood on their fore legs only, the hind legs being almost, if not entirely, lifted from the ground.

Choreiform contractions of various parts of the body were observed together with champing of the jaws and retraction of the commissures of the lips.

Sensation was also "modified."

The respiratory symptoms were restricted to the upper air passages, and consisted of rhinitis with, at first, a serious discharge which later became muco-purulent. There was a painful cough resembling that of whooping cough, and subsequently symptoms of suffocation.

The appetite was normal, but affected animals vomited after every meal, especially in the early stages of the disease.

In the majority of cases, the affected animals died in from 8 to 10 days. Some survived a month, and some made a complete recovery.

Post-mortem examination, bacteriological investigations and inoculation experiments have yielded entirely negative results.

Piot Bey.—The Recrudescence of Cattle Plague in Egypt. *Ann. Inst. Past.*, 1919, Vol. XXXIII, No. 3.

The good results following the introduction of the simultaneous method of inoculation against cattle plague among the animals on the State Domains led the Government of Egypt to order the systematic and general application of the method with the object of completely eradicating the disease from the country. Excellent results had been obtained and the work was progressing satisfactorily up to 1914 when events caused an interruption in the work. In some way or other cattle plague reappeared in the country, and during the following year spread through Upper Egypt and to practically the whole of Lower Egypt. While there was a considerable

stock of serum at the Institute at Abbasieh, virus, that is to say virus derived from cattle imported from Cyprus, was unobtainable owing to the closing of the Institute. Rather than use blood from indigenous animals, which are frequently infected with one or more kinds of piroplasms, for virus, the expedient was tried of rubbing the exposed mucous membranes with cotton wool saturated with virulent exudates from infected animals.

This method however proved almost invariably ineffectual, and it was therefore decided to return to the original method of using virulent blood.

The state of affairs in August, 1917, on the State Domains was as follows :—

(1) There were about 1,400 cattle which had been vaccinated in 1912, 1913 and 1914.

(2) 281 adults and 395 calves of from two to three years of age, bought in 1916 and 1917, which had not been vaccinated. The calves were collected into herds of from 40 to 100 on the seven principal farms.

On August 5th, the first suspected case was reported among a herd of 96 animals of two years of age. The next day but one, temperatures were taken and 12 animals shewing marked elevations were detected, and one of these was also shewing clinical symptoms. The following day this animal received about 120 c.c. of serum as a curative measure.

On August 8th, the blood of one of the animals was used as virus for the simultaneous inoculation of the other 11. This blood was kept on ice until the following day when it was used together with serum, which had in the meantime arrived, for the inoculation of the remaining 83 animals.

It is here noted that the blood used was found to contain Piroplasm bigeminum.

During the following days the animals were under careful observation and their temperatures were taken twice daily. The animal which had been given 120 c.c. of serum died on the night of the 10th with very severe lesions.

Of the 11 calves vaccinated on the first occasion, six shewed lesions on the same evening or on the next day. The same thing occurred in the case of one of the animals vaccinated on the 9th.

Of these 7 animals (this appears to be a misprint for 87) five died with characteristic lesions and two recovered. This is the usual proportion of recoveries in Egypt.

In view of the fact that 87 of the animals gave reactions to the inoculations, it is evident that they were susceptible.

In view of the result obtained, it was decided to extend the vaccination to all the unvaccinated animals and also to all animals that might be bought subsequently.

The virus used for the inoculations was obtained from two calves inoculated in series and kept in a portable ice chest for eight to ten days.

Six series of calves were inoculated fortnightly and this served to keep the virus going until the end of November.

From August 26th to 28th, 299 calves and 281 adult animals were immunized. The virus used was found to be free of piroplasms, as it was also in the five subsequent series of virus producers.

From September 2nd up to October 24th, five lots of cattle numbering 178, purchased during this period, were inoculated.

Seventeen of the animals bought during this period had been vaccinated during 1912 and 1913, and these were not revaccinated. None of them shewed infection.

It has already been seen that 98 per cent. of the first batch of calves reacted to the inoculations. In the case of three other batches numbering from 49 to 50 head, the percentages of reactions were 79, 83, and 76.

Among three lots of animals aged about three years, the percentage of reactions ranged from 68 to 77.

These figures indicate that increasing age gives increasing immunity.

This view is supported by the fact that of 459 adult animals vaccinated during the same period, only 229 reacted.

The author points out that in a previous paper he expressed the view, basing his opinion on two experiments, that immunization

of the mother alone is practically without result, but that immunization of both parents appears to confer complete immunity.

A fresh observation in support of this is brought forward, but definite opinion is reserved.

A calf, twenty-eight days old—the progeny of animals vaccinated respectively in 1914 and 1915—was inoculated along with its mother as a test on 27th August, 1917. Neither shewed any reaction to the double inoculation.

While no accidents occurred among the first batch of animals inoculated, it is pointed out that a few occurred among the animals done subsequently.

Of the two-year old calves, one died on the 13th day and one on the 17th day after inoculation.

The first of these shewed embolism of the left ventricle of the heart and evidence of atelectasis and embolism in the lungs. The animal had shewn a marked reaction to the inoculation and at the post-mortem the lesions of cattle plague were becoming cicatrized.

The second animal was in poor condition at the time of inoculation. It passed through a normal reaction which was followed at an interval of some days by a sudden rise of temperature to 40° accompanied by violent bile-stained diarrhœa, and complete loss of appetite. The animal died on the third day after the appearance of symptoms. At the post-mortem there was slight enteritis and marked congestion of the lungs: no enlargement of the liver or spleen and no evidence of piroplasmosis.

Among the 459 adult animals inoculated, there were also two accidents, both of which occurred among a single batch of newly purchased animals.

The first of these died on the 14th day after inoculation as the result of a severe attack of Texas fever complicated by tuberculous abscesses in the lungs.

The second animal died 17 days after inoculation having shewn vague symptoms of "malaria" and spasmodic contractions of the masseter muscles.

At the post-mortem examination, the spleen was found to be very greatly enlarged, and there was congestion of the intestines and

the lungs. There was no hæmaturia and no red serous exudate in the pericardium.

Neither of these animals had reacted to the inoculation.

If these deaths are considered to have been due to the vaccination, it in no way discredits the method, because similar deaths have been observed in very large numbers of cases among newly bought animals which have not been inoculated.

The facts collected during the course of the outbreaks referred to in this paper shew that immunity conferred by the simultaneous inoculation method persists for periods of at least five years. None of the animals inoculated during 1912-13 shewed the slightest sign of being infected, although no special precautions were taken to protect them from infection.

COCONUT: THE WEALTH OF TRAVANCORE.*

BY

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Introductory.

Travancore, that narrow strip of territory at the south-western corner of India, stretching from Cape Comorin in the south to Cochin in the north, having a length of about 174 miles from north to south, a maximum breadth of about 74 miles from east to west, and a total area of about 7,600 square miles, and inhabited by a population of about 3½ millions, is the largest and most prosperous Native State in the Madras Presidency. In point of size it is only about one-fourth ot the State of Mysore ; but its revenue is more than one-half of that of the latter. Every foreigner, who visits the country, is so enamoured of the richness and splendour of its natural resources that at the very first sight he calls it a land overflowing with milk and honey. Though this is an exaggeration, it is not without a small substratum of truth. Poverty there is in plenty in Travancore as in other parts of India ; but entire pauperism and absolute starvation are not so common as in other parts. Though occasionally crops fail on account of scarcity of rains, the country has never been visited by one of those dire famines which have at different times caused indescribable havoc and enormous loss of life in British India. What is the cause of this significant difference between Travancore and other parts of India ? Rice, which is the food of the people, is not being produced in sufficient quantity to meet local requirements

* A paper read at the Fifth Indian Science Congress, Lahore, 1918.

though it is the chief crop of the country. Local production amounts to only two-thirds of the quantity required, while one-third is being imported from Burma and other countries. Self-sufficiency in the matter of food production is not, therefore, the cause of the happiness and contentment of the people of Travancore. What else can it be due to? The answer will be self-evident to one who takes a trip in a boat through the long stretches of backwaters which extend practically along the whole length of the country. There one will see on either side miles and miles of lands covered over with thick and luxuriant groves of that beautiful and attractive species of the palms which botanists call *Cocos nucifera* and which is familiarly known to laymen as the coconut palm. It is this palm which has contributed mainly to the present prosperity of Travancore. From it the people derive their main income and from it the Government gets a large portion of its revenue. There is no part of it which is not useful in one way or another. The kernel inside the nut, which is the most valuable part of the coconut products, is used in India for culinary purposes either as such or in the form of oil which is extracted from it, and in Europe it is made into sweets, biscuits, and other articles. The coconut oil, which is the essential portion of the kernel, is being largely used in the manufacture of margarine, coconut butter, soaps, and candles. The cake, that is left behind after the oil is extracted, is a valuable cattle food and a still more valuable manure. The milk especially of tender nuts is a delicious drink the excellence of which can only be appreciated by those who have had the fortune to quench their thirst with it after a tiresome walk or a long ride. The juice, which is collected from the unopened spadix, when fresh and unfermented, is an equally refreshing drink ordinarily known as toddy; when partially fermented it becomes a slightly intoxicating drink; and when fully fermented and distilled it yields an alcoholic drink called *arrack*. The shell, which covers the kernel, is excellent fuel, and takes the place of coal in Travancore. The husk surrounding the shell, when soaked in water for about six months, washed, and cleaned, becomes coir from which yarn, cables, ropes, matting, foot-rugs, and various other articles are made. The dried sheaths

of flowers are used as fuel, the leaves when dried and plaited form excellent material for thatching houses, and the stem when fully mature makes fine beams and rafters for buildings. Here is a tree which supplies food and drink to man and gives him materials to construct a house to live in, and well does it deserve the name "Devavriksham" or "Kalpavriksham" (the tree of heaven), a name which has been ascribed to it in the ancient Indian literature and which is still current among the people of the Malabar Coast.

Origin of coconut cultivation.

As regards the origin of coconut cultivation in Travancore, different theories have been advanced. Some are entirely based on legends and others on linguistic and other evidences. The legend most widely believed by the people is that "Kerala," which is but another name for Travancore, was once under the sea and was reclaimed by the magic wand of God Parasurama, that the reclaimed country was parcelled out and distributed to a number of Nampudiri Brahmins whom Parasurama brought from the north, and that the "Kalpavriksham," the coconut palm, was given to the colonists by him as a heavenly gift. It is difficult to sift the chaff from the grain in such legends and to get at the truth underlying them, if any. There is, I believe, geological evidence to show that Travancore has been formed by the rise of the sea-bed by some movement of the earth, and there is also linguistic evidence to support the theory that the coconut palm is an introduction into the country from outside. Out of these facts the fertile brains of the ancient Indians must have woven the story of Parasurama, giving it a religious cloak, so as to appeal to the minds of the illiterate masses. This is all the justification that one can find for the Parasurama legend.

Coming now to the hypotheses based on linguistic evidence, it must be said that there is no unanimity of opinion regarding them. The one that is generally accepted is that "keram," a contracted form of "nalikeram" which is the Sanskrit word for coconut, was brought to India from Ceylon by the Singhalese, who crossed over somewhere about the 4th century A. D. and who now form the large

and progressive community of "Thiyyas" or "Eshavas." "Thiyyan" is considered to be a corrupt form of "Dwipan" or islander, and "Eshava" a corruption of "Simhala" or "Singhalese," the natives of Ceylon. The "keram," which the Singhalese imported, is also said to have given the name "Kerala" to the country in which it has thrived. The Tamil and Malayalam names for coconut lend support to the above theory. The Tamil name "Thenkai," from which the Malayalam name "Thenga" has been derived, means the fruit from the south ("Then" means south and "kai" fruit, *i.e.*, the fruit that was brought over from the south, presumably Ceylon). This theory appears to be plausible even on a consideration of the commonly accepted hypothesis about the original home of the coconut palm. Some are of opinion that it is a native of South America, while others think that it belongs to some islands in the Asiatic Archipelago, most probably Sumatra and Java. The latter appears to be more probable and is at any rate accepted by the majority of those who have investigated the question. From the evidence that has been collected it is not far wrong to infer that coconut was carried by oceanic currents from the Asiatic Archipelago eastward to South America and westward to Ceylon, and that from the latter place it was imported into India. Whatever be the source from which the palm has been introduced, there is no doubt that it must have established itself in the Malabar Coast from very early times. The ancient Sanskrit literature dealing with the Ayurvedic system of medicine contains many references to the medicinal properties of the different coconut products, which is sufficient proof of the antiquity of coconut cultivation in India. When once it has been introduced and its uses have become known to the people, the development of its cultivation must have taken place as a natural sequence of events.

Coconut industry in Travancore.

For a very long time, however, the uses of coconut products were little known outside India and probably even outside the Malabar Coast. When Europeans first opened trade with India they took no notice of this palm and its produce. Pepper was then

the chief article exported from the Malabar Coast, and the territory which produced it in abundance was known among the Europeans as the land of pepper. With the advancement of sciences in the 19th century it was discovered that various highly useful and valuable articles could be manufactured out of coconut products, and a demand thus arose for them in European markets. Till the outbreak of the present war Germany was the chief country to which these articles were exported, and there they were made use of in the manufacture of soaps, candles, margarine, etc. The magnitude of the export trade of Travancore in coconut products could be realized from the fact that during the three years before the outbreak of the war she exported on an average Rs. 1,82,00,000 worth of these articles annually, which represented nearly 50 per cent. of her export trade. The articles exported were chiefly raw products such as coconuts, *copra* (dried kernel), oil, coir, and fibre which together accounted for nearly Rs. 1,65,00,000. The position of coconut among the factors contributing to the prosperity of the country, to which I have already referred, will be evident from the above figures. I have also referred to the fact that Travancore imports one-third of the rice she requires for local consumption, *i.e.*, for about Rs. 1,25,00,000. The people grow coconut and sell its produce in foreign markets, and with the money thus received they buy rice from outside. But for the abundance of coconut produce and the large export trade that has become possible in consequence, the people would not have had sufficient money with which to buy the rice so essential to their living, and their lot would then have been quite different from what it is at present. Fortunately for them the country is so plentifully blessed by Nature, and the soil and climatic conditions are so congenial to the growth of the coconut palm, that they are able to get a handsome return from it without much labour or trouble. But, with better attention and care in the matter of cultivation and manuring, it is possible to increase considerably the income from this crop. The people, I am glad to say, have begun to realize the folly of not utilizing the blessings of Nature to the utmost advantage, and are at last bestirring themselves in the development of their coconut cultivation.

The area under coconut in Travancore is not after all much, and the outturn is not anything like what it is capable of yielding. Unfortunately there is no agency in Travancore for the collection of annual agricultural statistics and for the publication of periodical crop forecasts. It is not possible, therefore, to give accurate information about the acreage and yield. On a rough calculation it is estimated that out of the total area of the State (4,864,000 acres), coconut occupies only about 250,000 acres, and that the total output of nuts in a year may amount to about 500 millions on the assumption of an average yield of 2,000 nuts per acre, which, if anything, is but a conservative estimate. The export of *copra*, oil, and nuts accounts for about 325 million nuts out of the total production, and the balance of 175 million nuts is being consumed in the country itself. The export of 325 million nuts before the war brought into the country a sum of Rs. 1,82,00,000. If by paying better attention to cultivation and manuring the output of coconuts is doubled, which I shall show is not an impossibility, the quantity available for export will increase to 825 million nuts, which will raise the national income from coconut products to not less than five crores of rupees even if the export is confined to raw products such as *copra*, oil, coir, etc. These are being sent to foreign countries for being manufactured into different finished articles, and if this manufacture is undertaken in the country itself, there are immense possibilities of increasing its natural wealth still further. The very thought of this question overwhelms one with the vastness of the field that unfolds itself before the mind's eye for the development of the natural resources of even such a small State as Travancore, and what can one say then of the potentialities of such a vast continent as the British Empire?

Cultivation of the palm.

Before proceeding to show how the coconut industry of Travancore ought to be developed, I shall describe as briefly as possible how the palm is now being cultivated. It thrives best on the littoral area, particularly on that portion of the country which lies between the sandy deserts of the coast and the sub-montane

tract of laterite formation to the east of the backwaters. The soil best suited for it is a loose and friable sandy loam, which is generally met with in the area specified above. Looseness of soil, which will admit of the free passage of roots, is an essential condition to the successful growth of the coconut palm. Richness of plant foods seems to be a less important factor. If the soil is poor but loose, the roots will grow to a length of 20 to 25 ft. in search of food and will make good use of the materials available within that wide radius. On the other hand in a soil which is hard and impervious, however rich it may be, it does not show a healthy growth, unless such a soil is made friable by the addition of sand and lime. Abundance of moisture seems to be as essential to the growth of the coconut palm as looseness of the soil. Travancore has a rainfall varying from 30 to 250 inches per annum. She gets the benefit of both the south-west and the north-east monsoons which together cover a period of about seven months in the year, from June to December, and the only dry weather that she experiences is during the months of January to May. In places where the heat is most severely felt, the coconut palm is irrigated during these months, and at other places the soil is worked up to such a fine condition just before the cessation of the rains as to conserve sufficient moisture to enable the palm to tide over the hot season without much injury. If irrigation can be resorted to in such places the yield can no doubt be increased. But irrigation in these places is impracticable, and hence cultivators have to be satisfied with the diminished yield they get. Though a loose sandy loam is the ideal soil for the cultivation of the coconut palm, it is by no means confined to such soils in Travancore. The cultivation is being extended practically over all kinds of soil. The sandy deserts along the coast which contain little or no plant food, the heavy clay soils reclaimed from the backwaters, and the infertile lateritic soils of the hills and hill-slopes in the interior of the country are all being brought under this crop, the natural defects of the soils being rectified by artificial methods. The sandy deserts are enriched by the addition of rich silt from the backwaters, the fertile but impervious soils reclaimed from the backwaters are made porous by the addition of sand, and the poor

laterite soils of the hills are improved by the addition of sand and manures. By these methods almost every kind of soil met with in the low-lying and sub-montane parts of Travancore, where the climate is warm and moist and the temperature remarkably equable all the year round, varying only from 70° to 90°, has been made suitable for coconut cultivation. The only limiting factor is the presence of a hard and impervious sub-soil. Where the sub-soil is soft and porous to a depth of about 4 to 5 ft., there the coconut palm grows satisfactorily. Even steep slopes which satisfy this condition are being used for the purpose by forming terraces to prevent washing and to conserve rain water.

Among the varieties of the coconut palm met with in Travancore as many as 40 have been counted. They differ from one another in various points, such as colour, shape, and size of the nuts, thickness of the outer fibrous covering, thickness of the kernel inside, the oil-content of the kernel, and the period of maturity of the palm. In colour, different shades of green, brown, and yellow are met with. According to the size the nuts can be classified as small, medium, and large. The thickness of the fibrous covering and of the kernel and the oil-content vary considerably in different varieties. Under normal conditions some varieties begin to bear in 3 to 4 years and others in 7 to 8 years, and on this distinction the coconuts can be classified as early and late varieties. The life of early varieties is not more than 20 to 25 years, while the late varieties may live up to 100 years and more. In the selection of varieties for cultivation all the above factors, except perhaps colour, must be taken into consideration. The ideal variety is one which has the longest life and which produces medium-sized nuts having a thin fibrous covering, thick kernel, and high oil-content. Owing to the lack of sufficient care in the selection of seeds several undesirable varieties have been cultivated in Travancore, but through the advice of the Agricultural Department there has come about a decided improvement in this direction in recent years.

The seed nuts are usually collected from middle-aged palms. The nuts which ripen in the dry months of April and May are considered to be the best for seed. In harvesting the seed nuts some

cultivators take great care to prevent injuries to the embryo. The nuts that are collected are stored in buildings for a couple of months during which period they dry up to some extent and lose a great portion of the milk inside. They are then planted in specially prepared nurseries, usually in July. In a couple of months after planting the nuts germinate and in next June they will have thrown out 3 or 4 leaves when the seedlings are transplanted. On low lands, which are subject to inundations, experience has taught the ryots that it is better to plant 2-year-old seedlings. On laterite soils also, where there is trouble from white ants, it is advisable to plant 2-year-old seedlings only. Though the usual time of transplantation is the commencement of the south-west monsoon in order that the plants may establish themselves without the help of irrigation before the setting in of the hot weather in the month of December, it has been found from practical experience that if the seedlings are transplanted in December and irrigated during the first hot weather they become hardier and are able to withstand drought in subsequent years better than those transplanted in June. Of course, this method can only be adopted in places where there is facility for irrigation.

In low lands subject to water-logging the seedlings are planted on ridges which are made at first 10 to 15 ft. broad and at least 2 ft. above the water-level. As the seedlings grow up, the trenches in between the bunds are filled up and the level of the whole land is gradually raised until it is at least 3 to 4 ft. above the water-level. On elevated lands, which generally contain laterite soils, the seedlings are planted in pits, the size of the pit varying in proportion to the height of the land and the hardness of the soil. The biggest pits measure at least 4 ft. cube of which about 2 ft. are filled with surface soil and manure before the seedlings are planted, and the remaining 2 ft. are gradually filled up during the first 3 years after planting.

Among coconut cultivators of other countries the question is still under discussion whether it is advisable to cultivate catch-crops on coconut gardens. In Travancore it is invariably the practice to grow such crops, especially on lands which are not poor

in plant foods, for the first 4 or 5 years. The crops that are usually cultivated are cassava, other roots, pulses, banana, and dry land rice. Of these, cassava seems to be the least suitable, not because it is more exhausting than other crops, but because it is ordinarily cultivated without manures, while cattle dung, ash, green leaf, and other manures are usually applied to other crops. It is a bad practice to cultivate any catch-crop on coconut gardens without the application of manures, for in that case the soil fertility will soon get exhausted, and the growth of the coconut palm will to that extent be affected. But if catch-crops are manured properly, there is no danger in cultivating them for the first 3 or 4 years after transplanting the coconut seedlings. In the interests of the coconut as well as of the catch-crops it is advisable not to raise the same catch-crop every year. Different crops must be cultivated in rotation, prominence being given to pulses, and this is what is being done in Travancore.

In the matter of manuring there is much room for improvement in the methods of Travancore cultivators. They are no doubt aware of the fact that manuring will pay ; but owing to want of capital and sometimes owing to their negligence and indifference they are not doing all that they ought to do in the matter. At the time of transplanting they invariably apply some ash and a small quantity of common salt. This they do more with a view to prevent the attack of white ants on the seedlings. Subsequently most of the cultivators apply ash regularly every year, and some also cattle and sheep manure, green leaf, and occasionally some common salt as well. It is a common practice among them to apply a mixture of ash and salt to the crown of the palm which has been found to be an effective method of keeping off beetles. These manures will naturally be washed down to the ground by the rain and will become available for absorption by the roots. Thus two birds are killed with one shot.

We have already seen that one of the chief factors that contribute to the successful growth of the coconut palm is moisture, and that, except during the hot weather period of about five months, the rainfall in Travancore is sufficient to ensure the supply of the required

moisture to the soil. During the hot weather irrigation is not resorted to except in some portions of the sandy district along the coast; but in other places cultivators have found out from practical experience an efficient method for the conservation of moisture in the soil. In June, at the commencement of the south-west monsoon, beds are taken around the palms in order to collect rain water and let it percolate through the soil. By this method surface washing is reduced and the porous soil and sub-soil get thoroughly soaked. The rains continue till December, when the beds are filled up and the whole garden is given a thorough digging to a depth of a foot or so. By this digging the weeds are covered and the soil is reduced to a fine tilth, which helps in the conservation of the moisture that has been absorbed by the soil during the rainy season. A more efficient, but less expensive, method of utilizing to the best advantage the natural rainfall in the cultivation of the coconut palm than the one described above, it is difficult to think of.

From what has been said regarding the methods of cultivation commonly followed in Travancore, it will be seen that there are several excellent practices which the cultivators have learned from their long experience, and which can safely be recommended for adoption in countries where they are not known. Prominent among these are: (1) the addition of silt to sandy soils and sand to clay soils to correct the natural defects of soils; (2) the terracing of slopes to prevent surface washing; (3) the principles of the selection of seed nuts and the care bestowed on their collection; (4) the application of ash and common salt to the soil before transplanting the seedlings to prevent the attack of white ants; (5) the planting of 2-year-old seedlings on lands subject to inundation and on hilly lands where there is white ant trouble; (6) the cultivation of catch-crops between coconut palms for the first 4 or 5 years; (7) the application of ash and common salt to the crown of the palm as a preventive against the attack of beetles; (8) and last, but not least, the practice of making beds around the palms in June and of filling them up and digging the whole ground in December in order to collect and conserve as much as possible the rain water and utilize it to the maximum benefit in coconut cultivation.

Improvements by Agricultural Department.

By giving prominence to the good points in the methods of Travancore cultivators, I do not mean to say that their methods are perfect, nor that the practices referred to above are being adopted by all of them. There are many in Travancore who, out of ignorance or indifference, do not follow these practices, and one of the chief functions of the State Agricultural Department is to break this citadel of ignorance and indifference and to extend throughout the country the excellent methods that are being practised in some parts. Along with this work the department is also devoting its attention to the general question of the improvement of coconut cultivation in regard to certain aspects which are little known to Travancore cultivators, and which, though known, are neglected by the majority of them. I shall describe as briefly as possible the work that is being done by the department in this direction.

One of the chief defects of coconut cultivation in Travancore is overcrowding of the palms. Where there ought to be 50 to 70 palms only, 100 to 150 are usually planted. The evils of overcrowding are self-evident. In a thickly planted garden the palms at the periphery are found to be more productive than those in the interior, though there is no difference in the treatment. Those at the periphery get more light and air and hence are in a better condition. It cannot be said that Travancore cultivators are ignorant of the evils of overcrowding. There is a proverb current among them regarding the distance at which the palm is to be planted, and if they had only followed this wise saying of their ancestors they would not have made mistakes. The proverb says that on low lands the distance between the palms should be 4 *dhannus* (a dhannu = 10 ft.) and on high lands 3 *dhannus*. The proverb, if anything, errs only on the right side. A distance of 30 to 40 ft. appears to be more than the actual requirements. 25 to 30 ft. seems to be ample—30 ft. on low lands and 25 on high lands—and in that case the number of palms to the acre will be 50 to 70. In recent plantings, I am glad to say, these distances are being adopted.

In regard to the selection of varieties, we have already seen that the methods of Travancore cultivators, or at least of some

of them, are far from primitive or unscientific. The main objects of seed selection are to produce the maximum number of nuts and the maximum quantity of *copra* per acre (the dried kernel is what is called *copra*). Of the different varieties met with in Travancore, there are some which require only 1,200 to 1,500 nuts to make one *candy* (800 lb.) of *copra*; while in the case of others the number required goes up to 2,000 and 2,500. Varieties of the former class, which yield nuts of medium size, must be selected for planting. In the case of large nuts the number per acre will be proportionately small; and in the case of small nuts, though the number may be large, the kernel inside is so thin that the quantity of *copra* obtained from an acre will be comparatively less. The golden rule to be observed, therefore, is the selection of medium nuts with thick kernel. This rule has not been universally followed in the past, and hence very many undesirable varieties have come into actual cultivation. To prevent the repetition of this mistake, the Agricultural Department has during the last two or three years selected nuts of the desired types and sold them to the public. This work is being continued, and to enlarge its scope the department has also assisted in the formation of a private firm to carry on the same work.

The greatest possibilities in the improvement of coconut cultivation in Travancore lie in the method of manuring, and it is the solution of this question that has engaged the prominent attention of the Agricultural Department during the past seven or eight years. The department has carried out a number of experiments with different manures, most of which are still being continued, and has obtained highly encouraging results. The majority of soils of Travancore, except those bordering on the backwaters and the alluvial deposits on the banks of rivers, are deficient in humus, nitrogen, phosphoric acid, and lime. From a number of samples of soils analysed, it is found that the composition varies somewhat as follows: Nitrogen, 0·06 to 0·17 per cent.; phosphoric acid, 0·01 to 0·05 per cent.; and potash, 0·20 to 0·30 per cent.

The only plant foods which are present in anything like satisfactory quantities are potash and in some cases nitrogen also; but

even these cannot be considered sufficient for the requirements of the coconut palm. It has been calculated that a crop of 2,000 nuts per acre will remove from the soil about 18 lb. of nitrogen, 5 lb. of phosphoric acid, and 38 lb. of potash. If the requirements for the growth and nourishment of the palm are also taken into account, the quantities of plant foods to be added to the soil annually, in order to prevent its deterioration, must be not less than 24 lb. of nitrogen, 12 lb. of phosphoric acid, and 60 lb. of potash. This is of course in the case of a soil of medium fertility. But in the case of soils which are exceptionally poor in phosphoric acid and to some extent in nitrogen also, but fairly rich in potash, as Travancore soils are, the first two must be added in larger quantities, and the last in somewhat less than in the usual proportions. Travancore soils also contain very little lime, and lime is essential to such a longstanding crop as the coconut palm to neutralize the acids that are formed in the soil and to improve its general texture. Common salt has been found to be a valuable manure to the palm. The Travancore ryots have learned it by experience, and the scientists have declared from their analyses that as much as 60 lb. of sodium chloride are removed from an acre by a heavy crop. Near the coast, where there is the possibility of the sub-soil being infiltrated with brackish water, the application of common salt can be dispensed with ; but in other places it is indispensable. Keeping the above facts in mind, I have prepared a manure for the coconut palm consisting of ingredients available in Travancore. I have not gone in for artificials because they are not easily available, and, even if available, they are too costly to become widely popular in the near future. My mixture consists of 10 lb. of oilcake, 20. lb. of ash, 2 lb. of fish refuse, and 1 lb. of common salt per tree. In the place of fish refuse bonemeal can be substituted, and in soils whose lime contents are poor, 10 to 15 lb. of quicklime are also added once in 2 or 3 years. The above mixture has the following average composition: Nitrogen 0·53 per cent., phosphoric acid 1·01 per cent., and potash 0·74 per cent.

Several experiments have been carried out with this mixture both by the Agricultural Department and by private persons under the supervision of departmental officers, and all of them have

produced exceptionally good results. I shall give here the results of a few such experiments.

Serial No.	No. of palms manured	Year	Total produce in nuts	Average yield of nuts per palm
1	10	1909-10	44	4·4
		1910-11	67	6·7
		1911-12	223	22·3
		1912-13	480	48·0
		1913-14	573	57·3
		1914-15	669	66·9
		1915-16	919	91·9
2	100	1912-13	4,000	40·0
		1913-14	7,000	70·0
		1914-15	6,000	60·0
		1915-16	9,000	90·0
3	263	1911-12	11,300	43·4
		1913-14	19,400	73·8
4	250	1912-13	3,989	15·9
		1913-14	9,857	39·4
		1914-15	10,042	40·1
		1915-16	11,862	47·5
5	100	1914-15	1,193	11·9
		1915-16	2,309	23·1
		1916-17	4,167	41·7

The trees in the first series were in a very poor condition at the commencement of the experiment owing to long neglect. The second and third series were conducted on lands of medium fertility and with trees which were not so badly neglected; and the last two series on poor lands and with trees badly neglected for a long time. The statement given above clearly shows that there has been phenomenal increase in the yield of nuts in consequence of regular manuring. The highest yield obtained is nearly 92 nuts per palm. It has

taken seven years for long neglected trees to produce this yield. Trees which have not been so badly neglected have come up to this standard in four years as the second series of experiments shows. In the last two series the trees were so badly neglected that the yield has only increased to 47 and 41 nuts respectively in three to four years. It is sure to increase still further in subsequent years and come up to the yield of the trees in the first series in another three or four years. The lesson that these experiments teach is that under proper manuring the yield of coconuts will increase to as much as 90 nuts at least per palm per annum. When dealing with the output of coconuts in Travancore in one of the previous paragraphs, I have stated that the average annual yield for the whole of Travancore can be put down at 2,000 nuts per acre. Assuming that the trees are planted at 70 to the acre, this only works out to an average yield of 28½ nuts per tree. The numerous experiments conducted by the Agricultural Department have proved unmistakably that this average yield can be more than trebled. In the face of these facts, does any one still think that the statement I have made in the earlier portion of this paper, namely, that the output of coconuts in Travancore can be doubled, is an exaggeration ? I have been making a special study of the problems of the coconut industry in Travancore, and I am convinced that it has a great future before it, and that the country has in this industry great potentialities for increasing its wealth and for adding to the material prosperity of its population. What is it that has to be done for the development of these potentialities ? The answer is simple. Spread knowledge among cultivators and afford them all possible facilities for the purchase and use of manures. The Travancore Durbar is no doubt doing something in these directions through its Agricultural Department ; but there is a great deal more remaining to be done, and this is all that I can say about the matter in this connection.

PESTS AND DISEASES.

Several other problems connected with the coconut industry are engaging the attention of the Agricultural Department, for example, the method of manuring, *i.e.*, whether manures should

be applied in one complete circle around the palms or in half circles or in one-third circles; the question of breeding coconuts in order to produce a variety possessing all the good qualities which I have referred to when dealing with the selection of seed nuts, and several other kindred problems. As no satisfactory solution of these problems has yet been arrived at, I do not propose to deal with this part of the department's work at present. Nor do I wish to take up your time by entering into a discussion of that wide and important subject of pests and diseases of coconut palms. A full treatment of this subject will require a separate paper to itself, and much more time than I have at my disposal now. I may simply mention, however, the serious pests and diseases that Travancore cultivators have to contend against.

Among the pests the most serious are the rhinoceros beetle (*Oryctes rhinoceros*) and the palm weevil (*Rhynchophorus ferrugineus*). Since 1914 a new leaf-eating insect has also been found to attack the coconut palms. The hairy caterpillar of this insect eats away the green blades of leaflets leaving only the mid-ribs. It belongs to the family Limocodidæ, and a similar insect found on coconut palms in British Malabar has been identified by the Imperial Entomologist as *Contheyla rotunda*, Hmp. From all appearance the insect found in Travancore seems to be the same. In Malabar its outbreak was observed for the first time in December, 1916, and in Travancore in December, 1914. The Travancore Entomologist has discovered a natural enemy of this pest in a hymenopterous insect by which it has been found possible to control it.

The coconut palm is subject to many infectious diseases. The commonest of these are: (1) Leaf disease, caused by *Pestalozzia palmarum*; (2) Bud-rot, similar to the one attacking the palmyra palms in the Godavari District, caused by *Pythium palmivorum*; (3) Stem-bleeding disease, which has been fully investigated by the Government Mycologist, Ceylon, and which he attributes to *Thielaviopsis ethaceticus*; (4) Root disease, which has been investigated by the Imperial Mycologist, India, and the Mycologist of the Imperial Department of Agriculture, West Indies, and which is attributed to a fungus of the genus *Botryodiplodia*. All these diseases are seen

in Travancore—the first three only in mild forms of a sporadic nature, but the last in a more serious form over a wider area. The root disease has been in the country for well-nigh over half a century ; but the people took no notice of it, and the Durbar had no knowledge of it till 1897, in which year some of the owners of affected palms presented a memorial inviting the attention of the Durbar to the serious nature of the disease and praying for help. At first the Durbar did not think that the matter was a very serious one; but when the authorities fully realized the seriousness of the situation they applied to the Government of India for the services of a mycologist to investigate the disease, and accordingly Dr. E. J. Butler, Imperial Mycologist, India, was deputed for the work in 1907. He went over to Travancore, investigated the disease, submitted a report to the Durbar, and published an account of his investigations in Bulletin No. 9 of the Agricultural Research Institute, Pusa. Most of the suggestions of Dr. Butler, such as segregation of infected trees in isolated areas, propagation of disease-resistant varieties of the palm, improving the general health of the palm by better cultivation and manuring, etc., have been given effect to, in the result that the spread of the disease has been arrested and a substantial improvement in the general condition of the palms in the infected areas has been effected. But the most important suggestion of Dr. Butler, namely, destruction of all infected material, has not yet been put into practice on account of the serious objections of coconut cultivators. The coconut palm and the cow are looked upon by Travancore Hindus with a certain amount of sacredness. The name "Devavriksham" is a sufficient indication of this fact as far as the palm is concerned. On religious grounds, therefore, the cultivators object to the destruction of the palm. They also object to it on sentimental grounds. A man who has planted and nursed a palm cannot brook the idea of killing it. Destruction is objected to on economic grounds as well. A diseased palm does not die all at once. It lingers on for five to six years, and during this period it continues to yield some nuts, though greatly diminished in size and number, till the very last stage, and the owner is not prepared to lose the income, however small it be, which he gets

from his diseased palm. The last and the most serious objection is based on reasoning from the analogy of human diseases. What the cultivators say is that a plant suffering from a disease ought to be cured as human patients are and not to be summarily disposed of by destroying it. There is no use in arguing with people of this nature. They will never be convinced of the necessity of such a radical cure as the destruction of all infected material for the eradication of this deadly disease and for saving the otherwise prosperous coconut industry of the country. Persuasion has been tried and has failed, and the only course left open is compulsion. The Durbar is convinced of the necessity of legislating on the subject and action is being taken in the Legislative Council.

Great industrial possibilities.

The coconut palm supports a large portion of the population of Travancore. Besides those actually engaged in the cultivation of the palm, the industries connected with its produce give work to more than 150,000 persons. The most important of these industries is the manufacture of coir yarn from the coconut husk. It is carried on as a cottage industry by the people living on the coast and on the sides of lagoons and backwaters. Green husk is soaked in water for about six months, is then taken out, beaten with a wooden flail, and manipulated by hand to separate the fibre from other tissues, and the fibre is thoroughly cleaned also by hand and twisted into yarn with the help of a small hand-wheel. The finished yarn is graded according to its fineness and colour and sold to merchants. This industry is practically in the hands of women of the poorer classes. The husk is generally bought and soaked by petty merchants, and the soaked husk is sold by them in small quantities to women. A woman usually buys about 2 annas worth of soaked husk every morning, and by evening she prepares yarn and sells it back to the merchant for about 4 annas, thus making a profit of 2 annas. Before the outbreak of the present war the price of green husk was something like Rs. 10 per 1,000, and the cost of labour and other charges for soaking and preparing yarn varied from Rs. 15 to Rs. 20. The husk of 1,000 nuts would yield 200 lb. of yarn, the price of which in

Travancore before the war was Rs. 30 to Rs. 35. This was the price at which yarn was being sold by petty merchants to wholesale exporters. The former were thus making a profit of Rs. 5 to Rs. 10 on an investment of Rs. 20 to Rs. 25. The wholesale merchants, mostly Europeans, who exported the article to foreign countries, must have been making considerably larger profits. The yarn that went to those countries was being used for the manufacture of cordage, matting, rugs, and carpets, and the manufacturers must have also been making very large profits from their business. Here is an industry which is capable of yielding enormous profit, and owing to the lack of industrial spirit in the country the lion's share of it goes to the more enterprising nations of the world. Travancore exports annually about Rs. 57,00,000 worth of coir, and if all this coir had been manufactured into finished articles in the country itself, she would have probably got another Rs. 57,00,000. This is indeed a serious loss to the country, but still greater is the loss that accrues from the export of *copra*, oil, and nuts. The aggregate value of the annual export trade in these articles before the war was about Rs. 1,08,00,000. If the manufacture of margarine, soaps, and candles out of these articles, which is now being carried on in foreign countries, had been undertaken in the land of the palm itself, another crore of rupees could have easily been added annually to the income of its people. India, as a whole, is backward in industrialism, and Travancore is even more so than India. Even in this war time, when every part of the British Empire exhibits an unusual awakening in matters industrial, Travancore continues in the same old groove. The war has hit the country very hard. Owing to the shortage of tonnage its coconut products cannot be sent out. The price of nuts has fallen to Rs. 20 per 1,000, while before the war it was as high as Rs. 65 to Rs. 70, and even at the reduced price there is no one to buy them. If things continue like this for a few years more, which God forbid, the much talked of prosperity of Travancore will have to make way for a chronic state of poverty. Such a catastrophe could certainly be warded off if the people would only wake up from their slumber, realize the immense possibilities that exist in their country for the development of coconut industries, and go forward with a

dash, start these industries boldly, and invest their money in them, having regard to their own interests and the interests of the country. But I doubt very much whether they will do it. At any rate they have not begun to do it, and in the meanwhile other people have come forward to take their place. It has been announced in newspapers lately that that enterprising firm, the pioneers of gigantic industrial undertakings in India, Messrs. Tata & Sons, have decided to establish a factory at Cochin for the manufacture of margarine and other articles out of coconut oil. When this project becomes an accomplished fact, which I hope will be very soon, the firm ought to be in a position to buy up a large portion of the coconuts produced in Travancore, Cochin, and Malabar, and afford relief to the coconut cultivators of these territories from the hardship which they now suffer on account of the want of shipping facilities. The people of Travancore have received the announcement of Messrs. Tata & Sons with universal joy, and are eagerly looking forward to its early fulfilment.

Selected Articles.

THE SOURCES OF THE MILK SUPPLY OF POONA CITY.*

BY

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THE improvement of the supply of milk to Indian cities has been a subject of very serious consideration in many parts of India in recent years, and nowhere more than in the Bombay Presidency. The matter was brought into prominence by a paper on the subject which I read at the Agricultural Conference in Poona in 1913, in which I gave the results of a careful examination of the milk supply of Poona City in that year. This showed that the milk available was insufficient in amount, was exceedingly poor in quality, and was to a very large extent produced under highly insanitary conditions.

Shortly after this the matter was considered on a more general basis by a committee presided over by Mr. G. F. Keatinge. The report of this committee confirmed the essential conclusions of my paper of the previous year, and made a large number of recommendations. In general while emphasizing the extreme complication of the problem of city milk supply in Western India, they considered that it would ultimately be solved by the organization of supply from cultivators and others keeping cows and buffaloes under natural conditions at a distance (often at a far distance) from the town and by the improvement of transport which will make it

* A lecture delivered before the Deccan Agricultural Association, Poona.

possible to place such milk on the market in good condition. Lack of knowledge of the difficulties which were likely to arise led, however, the committee to recommend that a single large city should be selected, the whole question of its milk supply investigated, and the most suitable directions for its improvement worked out at the cost of Government. The beginnings have now been made of such an investigation in the case of Poona, and I wish to place before you some of the data which we have obtained. I may say at once that I do not yet see the way clearly in which all the difficulties will be removed, but I always feel that to know these difficulties is the first step towards meeting them.

The first weakness of the present milk supply in nearly all cases is its deficiency in quantity. In Poona, in 1913, I found that the total milk available daily from all sources was under four ounces daily per head of population. This small supply, to a population which would use milk if it could get it, means a very dear supply and a very much adulterated supply. In fact, any attempt to stop adulteration, without at the same time increasing the quantity available, increases the dearness of the milk and hence the power of the people to get it. The price of pure milk in Poona City was already 50 per cent. higher than that customary in cities in England before the war, and it was at the same time difficult to obtain. This high price occurs in a country where the average resources of the people are very much smaller than in Europe.

The first problem, therefore, was to increase the supply of milk. At present there are three sources from which milk is obtained. In Poona 78 per cent. of the total is got from animals kept inside the city, either by professional *gowalis* as a business, or by private householders for their own use. The second source of supply consists of milk brought in from the surrounding villages where milch animals are kept in part by professional *gowalis*, and in part by cultivators as a secondary source of income. In Poona this comprises practically all the remainder of the supply. The third source, which has been negligible in the past in the case of Poona, is the organization of the supply of milk from more distant villages where it is produced by cultivators, under cheap and

natural conditions, but where at present the difficulty of getting it to market prevents it being taken to the cities.

Of these sources of milk, the first, I feel, cannot be materially increased, owing to the increasing population in the city. Nor is it desirable that it should be increased. The milch animals are usually kept under unnatural conditions, nearly always insanitary, and the milk must necessarily from the nature of the case be dear. With regard to the second source of supply, namely, the surrounding villages, the organization of this supply is already being taken up by co-operative societies and others. If it pays to produce milk for city use in these villages the organization is not a very difficult matter.

The third source of supply has not, however, been exploited at all. And yet it was known that milk was produced at what seemed extraordinarily cheap prices at places little beyond the present sources of supply. I therefore decided to take four areas, all accessible from Poona by roads or rail, and all beyond the present range of supply, and investigate, village by village, (1) what is the present possible supply of milk: (2) at what price it can be purchased in the villages both in the cold and the hot weather; (3) the likelihood of the increase in the supply if a sure market was obtained; (4) the quality of the milk which could be available. In doing this I have to thank my assistant Mr. V. G. Patwardhan for his devoted work in collecting data in all these areas, and Mr. S. V. Shevde of Talegaon (and Mr. Patwardhan working together) for a very exhaustive examination of the situation and its possibilities in his own area.

The four areas which were selected as places where good milch cattle are or have been kept were as follows:—

(1) The group of villages at the foot of Singarh, situated from seven to fourteen miles to the south of Poona and connected to the city by a good and fairly level road.

(2) The group of villages near Khed Shivapur. This village is situated fifteen miles due south of Poona by a first class road, but between the two places there lies the Katraj Ghat.

(3) The group of villages in the valley of the Indrayani river round the small pilgrim centre of Alandi. This lies twelve miles almost due north of Poona with which it is connected by a good road.

(4) The group of villages round Talegaon station on the G. I. P. Railway, connected with Poona in about an hour by a frequent and excellent service of trains.

The first conclusions which appeared from our inquiries were—

(*a*) that in recent years the milch cattle in all these centres appear to have been decreasing rapidly;

(*b*) that the relatively low price of milk is due to a lack of demand only, for a comparatively small local demand, as at Alandi, raised the price to a figure approaching that in Poona City;

(*c*) that the milk capable of being obtained under present circumstances was an exceedingly variable one, and in many cases almost disappears in the hot weather;

(*d*) that the milch animals kept yield extremely little milk per head.

The decrease in the number of milch cattle seems to be very considerable, when our figures are compared with the last cattle census in 1915, in all these areas. It is, of course, possible that (owing to the well-known reluctance of the people in Deccan villages to give particulars regarding their cattle) one or other of these enumerations is not entirely correct, but I feel that this can hardly account for all the difference. In the Singarh area the decrease in milch cattle (cows and buffaloes) in five groups of villages (*Mouzas*) amounted to 37 per cent.; in the Khed Shivapur area it reached 26 per cent. for sixteen groups of villages. The number may in both these cases have been affected by the fact that the investigation was done at the height of the hot weather, but the difference, I think, is not very material. This cause was not, however, dominant in the Alandi area, where the decrease was 37 per cent., in spite of the enumeration being done in the rainy season. At the Talegaon villages the decrease appears to be about 29 per cent.

This decrease is alarming, and, making every discount, I am inclined to think it is real. It is attributed by the people concerned to various causes, notably to the increased stringency of forest regulations, to a shortness in the amount of fodder in the absence of forest grazing, and to absence of ready money among the villagers. It has undoubtedly been aggravated by the ravages of rinderpest in recent years, which have caused very great losses indeed, and also to serious outbreaks of foot-and-mouth disease. The investigation of the causes of this reduction in the milch cattle demands, however, another and special study.

The price of pure milk in the areas in which there is no special local demand varies from sixteen to eighteen pounds per rupee. For this amount the morning milk would be brought to a depôt in one of the villages, provided the distance is not more than two or three miles. This might also be done with the evening milk, but I am not quite sure. I think, too, that for this price with a shrewd purchaser, unadulterated milk could be secured. The higher price would have to be paid, of course, in the hot weather.

In one of the centres examined, Alandi, there is a local demand for milk chiefly for pilgrim visitors to the place. This demand, variable and uncertain as it is, raises the local price of milk to ten to twelve pounds per rupee—a figure not much below that which it fetches in Poona. This occurs in spite of the fact that the Indrayani valley in which Alandi lies is an excellent place for cattle and that there is a very large number of milking animals in the neighbourhood.

One of the biggest difficulties met with is, however, the extreme variability of the supply. In the months from September to January (cold weather) there is often enough spare milk to form the basis of a supply, while in the remaining months of the year there is little or none to be had. I will illustrate this point from my figures. In a group of villages round Singarh the amount of milk available partly in the cold weather for sale runs about forty to fifty gallons: in the same group in the hot weather there is certainly not more than ten gallons per day. In another and larger group round Khed Shivapur, in the cold weather the surplus available

for sale amounts to about 140 gallons daily. In the remainder of the year this gradually sinks to less than 30 gallons. The same difficulty is found everywhere, and I suppose will always remain until fodder is more largely grown by the people and preserved as silage or in some other manner.

The yield per head of the milch animals in a Deccan village appears to be astonishingly small. According to the people it only amounts to about two pounds per day per milking animal and sinks to one pound per day in the hot weather. It must be remembered, however, that in a large number of cases, particularly among cows, this amount is obtained after the calf has been fed, and where the breeding of a good working bullock is a matter of dominant importance this may well take a very large share of the milk produced.

In some respects, therefore, the results of our investigation of the present milk possibilities of a number of likely areas near Poona are disappointing. They show that at present the amount of milk available is small, and, that being the case, the price very easily rises to a figure which is no use for the supply of Poona. They show also that the yield of milk from existing animals is very small, and that the difference between the quantity in different parts of the year is so great that the milk available almost disappears in the hot weather. The question, however, at once arises as to how far the quantity available is likely to increase, and the keeping of milch cattle can be taken up on a larger scale and on a more satisfactory basis if a regular and certain market is provided.

I may, at once, say that, except at Alandi where there is a certain local demand, the people themselves say that, provided a ready and constant sale is guaranteed, they will go in for more milch animals and be able and ready to provide more milk at the present prices. In some villages in the neighbourhood of Talegaon, the people were particularly emphatic. "If you want the milk," said they, "we will provide it, but get the business started."

The matter is, I think, ripe for experiment, and in one case, that of Talegaon, a certain amount of experiment has been made by my friend Mr. S. V. Shevde, and I propose now to describe what

has been done there, the difficulties met with, and the way in which the matter may possibly be brought into practice on a considerable scale. I want to give a perfectly frank statement on the subject.

The experiment in question was started in August, 1917, from a village which was stated to be able to give 100 pounds of milk per day, and the people were asked to bring the morning's milk to the village *chavadi.* No check was possible on adulteration at first, but a warning was given that adulteration would wreck the scheme. The village chosen was about two miles from the depôt near Talegaon station by a short cut or three miles by a regular road, and the milk was brought to the depôt between 9-30 and 10-30 A.M. at a cost of two annas per coolie employed.

For the first few days the milk was brought in good condition at 16 pounds per rupee and cash was paid. Then the first difficulty arose in that the producers began to mix fresh milk with the milk from the previous night's milking. It was quickly found that if this was done the combined milk quickly became sour and was unfit for sending to Poona, but the cultivators took the stand that they could only continue to give us the morning's milk if we bought also the milk of the previous evening. This meant the organization of purchase of the evening milk also; a more difficult matter, as, at night, it was more costly to carry to the depôt, requiring two coolies instead of one and so doubling the carrying charges.

The next difficulty was that the milk which had been quite good at first rapidly began to be adulterated largely with water. *So far* the provision of a lactometer and its use by the milk collector has met this difficulty. The people, in fact, having once tasted the advantages of a regular sale practically at their doors, did not wish to risk their market and have brought decent milk again. So far the average fat content of the morning's milk is 7·2, and of the evening milk is 5·1. This is likely to be always the case as there can be better supervision in the morning.

The regularity of supply has been perfect, showing that in this matter the cultivators can be depended on.

The next difficulty has been the keeping of the milk after receipt. So far the night milk has been simply placed in open vessels in a cool and airy place, and has been despatched to Poona by the train reaching there at 5-30 A.M. It is distributed before 8-30 A.M. Thus the milk, taken from the cow between 6 and 8 P.M., is delivered in Poona exactly twelve hours later. Even in the months between August and November, 1917, there has been some difficulty about it going sour with no greater precautions than those indicated. About three times a month it has been slightly sour, and this is, of course, fatal. It is evident that the evening milk cannot be delivered in Poona from Talegaon unless some form of artificial cooling is used or unless the milk is pasteurised.

The difficulty is greater with the morning milk. This arrived at the depôt at about 10-30 A.M., the cows having been milked at 7 A.M. and the milk having been carried in the sun. It reached Poona at 12-45 P.M. and is delivered by about 2 P.M., though it is not usually used until the late afternoon. In this case, the danger of going sour was considerable, and it quickly became evident that unless a cooler at least, and possibly a pasteuriser, is installed at Talegaon a trade in the morning milk is impossible.

This involves a greater expenditure at Talegaon for preserving the milk. Luckily ample well water is available for cooling and is always fairly cool. Well water rarely is above 70° F. and often considerably below this, and with its use it will be possible to keep the milk, both evening and morning, at a temperature which will prevent it going sour. This is the next stage of our experiment. If found not sufficient, it will be necessary to instal a pasteuriser and this will mean considerably greater initial cost.*

In general our inquiries at Talegaon show as follows. The conclusions would probably be the same for many of the stations in the large grass areas between Poona and Lonavla.

(1) Talegaon is a good centre for milk supply, and with a little organization about 1,000 pounds of milk would be available in the

* A pasteuriser has now been put in.—(H. H. M.)

cold weather, and perhaps half this amount in the hot weather, within a distance of not more than four miles of a depôt near Talegaon station. The price will be from 15 to 16 pounds per rupee at the collection centres.

(2) A constant demand will lead to a fairly rapid increase in the number of milch animals kept and to better feeding of the animals, provided cash is paid for milk.

(3) The organization of the supply to Poona will involve treatment of the milk at least by cooling and probably pasteurising, as arrangements cannot be made for its certain delivery in Poona much less than twelve hours after milking.

(4) The disposal of the milk in Poona in the morning presents few difficulties; that arriving in the city in the afternoon is more difficult but can, I think, be got over.

(5) The organization of this supply would mean an initial expenditure of about Rs. 2,500, and if 500 pounds of milk a day were supplied, it should yield a profit of from Rs. 100 to Rs. 250 per month, without counting interest on the investment.

Other difficulties would arise undoubtedly, such as the demand falling off when Poona is plague-infected, and the like. But I think that the scheme outlined gives a sufficient chance of success to be gone on with, and I feel that there is every chance of the supply growing to an extent which we can hardly conceive at present.

What may be done at Talegaon may also be done probably at a large number of other centres situated in an equally favourable or more favourable position. I have already heard that similar schemes have already been mooted at other stations near Poona. If these work out, we shall have taken a step in the same direction as has been followed in practically all large towns in western countries, where the supply of milk from considerable distances, by collection from genuine farmers, has gradually replaced the supply from town *gowalis*, which was almost universal a generation ago.

Our experiments have not gone so far in the other centres where our inquiries have been made as at Talegaon. But there

seems reason to suppose that milk can also be successfully supplied by road where there are good dairy centres or centres with good dairy possibilities. Such a one is Khed Shivapur and the neighbourhood. Here the organization would probably have to be different, though I speak with caution, as sufficient experiment has not yet been made. The real difficulty in these road journeys is the rapid transit to the city, and the only means of effecting this seems to be by motor, the pasteurising being carried on in the city. To do this would need a very large supply—larger than seems to be available at present. But I prefer to leave the discussion of this matter until our experiments have gone further.

On the whole, therefore, our inquiries show that the supply of milk to cities from outside is beset by difficulties which do not occur elsewhere in the same form. The fundamental difficulty is probably the low yield of the animals, and the fact that the people trust to casual supplies of fodder and have not learnt the use of silage or its equivalent. But there seems reason to suppose that these difficulties can be got over, and once the movement is started, it will, I feel, get constantly increasing momentum. Once the supply of milk is adequate in the city, I believe the difficulties of regulation of quality and securing of a sanitary supply will solve themselves.*

* Since the above was written, a regular organized supply is being obtained from Talegaon, where a pasteuriser has been installed, and it is hoped to reach 700 pounds per day in the cold weather of 1918-19. If as successful as promises to be the case, I shall hope to give an account of this experiment and its difficulties later on.—(H. H. M.)

IMPROVEMENT OF COFFEE BY SEED SELECTION AND HYBRIDIZATION.*

BY

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Ever since Mr. Cameron called attention to the possibilities of it in his report on a visit to Coorg in 1899, a certain amount of work has been done along the lines of hybridizing coffee to raise a new strain which will bear more heavily than the ordinary *arabica* and be more disease-resistant. A fair measure of success has been attained in several places, notably in South Mysore by Mr. Crawford, and by Mr. Hamilton at Chundrapore, and by Mr. Jackson in South Coorg, who has succeeded in raising on a large scale a very satisfactory hybrid which comes true to seed. It is to be hoped that before long this seed will be on the market as soon as Mr. Jackson has supplied his own requirements. Again, at Doddengooda, in South Mysore, Mr. Kent has got established a good strain of coffee which may or may not be a true hybrid ; its history is unfortunately not known with accuracy.

The work of making hybrids is long and tedious and scarcely suited to estate conditions, however, and I still hope some day to see this work being done by an Economic Botanist on a special coffee garden. As I have said before, it would pay coffee planters to establish such a station and an expert even though they would be working more or less for posterity.

What I wish to speak of to-day, however, is a simpler matter which could, and ought, to be undertaken by every coffee planter,

* Speech delivered at the Coffee Planters' Conference held at Mysore in July, 1918.

namely, the selection of seed. A tremendous improvement can be made in the strain of any plant by persistent seed selection, and many of our economic crops are being annually improved by this method alone.

The starting point is what everybody has, "the best tree on the estate." I am constantly shown this in the course of my tours, but I am seldom or never shown what I want to see—the fields of coffee which have been planted with plants raised from the seed of this tree. Indeed the method of taking coffee seed, for planting nurseries, which I see going on, is as a rule a most haphazard one. There is no selection about it and in most cases no one can tell from which trees the seed came, not always even which field. This system is all wrong from start to finish, and in my opinion it accounts to a very considerable extent for the deterioration of the strain of coffee which has undoubtedly taken place in some districts.

As I say, the starting point for selection work is the "best tree on the estate," or the best several trees, judged by their yield under all circumstances, even in bad climatic seasons, the shape and habit of the bush, its freedom from diseases and its resistance to leaf disease and scale insects. Having chosen a few trees like this the next thing to do is to cut out the coffee trees round them, to give them ample space, light, and air, and then to make arrangements for netting them when they are in flower. To do this four stout posts should be put in the ground at the corners of a fourteen-foot square, each post about ten feet high, and a mosquito net made to fit over them so as to completely enclose the whole bush. It is a good plan to sew a valence of stout cloth round the bottom edge of the net which can be laid on the ground and have earth piled on it to keep the net steady and prevent it being blown about by the wind.

The blossom set under this net must be self-fertilized, which is an important point. If allowed to set in the open one has no control over the pollen used, and it may come from the worst tree on the estate. Seed self-fertilized will come true to a large extent and reproduce the characters of the parent tree.

This procedure will no doubt decrease the normal crop of the tree but this does not really matter, enough seed will usually be

obtained to plant up a fair-sized nursery. It is possible that the introduction of bees under the net might help the pollination and increase the crop. This has been tried, but I understand that the bees did nothing but fly round and round the net trying to escape. This may have been because the net was not big enough, and more observations on the point are required.

As soon as the fruit is set the net may be removed and stored for future use. Work should then be begun on the preparation of the nursery which is to receive the seed, and this nursery should be made with all the skill and experience at the command of the planter. It is a special nursery worth infinite trouble and expense to ensure its success. The berries should be gathered when as ripe as possible and pulped by hand and only the best seeds chosen. Peaberry need not be rejected, as peaberry is an accident and not an inherited character.

The nursery plants should be spaced widely and most carefully attended to and sprayed with Bordeaux Mixture, if necessary, to protect them from attacks of leaf disease. When ready to plant out, a second selection should be made, and this second selection is most important. Only the very best plant should be put out. A weakly plant or one of bad shape should be rejected as should even doubtful plants. In my opinion it is a very good nursery indeed from which 75 per cent. of the plants can be put out. It often happens that on looking at a new clearing I see a corner which is very poor compared with the rest, and I am told that it was "planted with the tail-end of the nursery." Well, it does not pay to plant out that tail-end of the nursery and it is better to leave a portion unplanted for a year and keep it under a green dressing crop than to put out poor plants.

The next stage is to select the best three or four bushes from the clearing planted from the first selected seed as soon as they come into bearing and to repeat the process. By this means each clearing would improve in strain and in course of time a vigorous strain of coffee would be built up. I am inclined to think that this is what has happened in the case of Mr. Kent's plants accidentally. The seed was isolated in a village garden and

a selected strain has been established which is as good as a hybrid.

I am convinced that a process of selection of this sort over a period of 10–20 years would make a great improvement in the yield and welfare of the coffee estates, and that it would be a better plan of rejuvenation than trying to introduce new seed from other countries which will not be selected seed and will need acclimatization and subsequent selection in any case. On any estate all supplies put out should be grown from selected seed and special nurseries.

Experiments with seed selection have been carried out for years by the Department of Agriculture in the Dutch East Indies. In these experiments the seeds from each selected tree are sown and cultivated separately, and the growth and production of the different lots are compared amongst themselves, and the tree which gives the most vigorous and productive descendants is chosen to provide seed for the future. In many cases it has been found possible by this method of seed selection to separate a large number of varieties which have been proved constant by successive sowings. *Coffea arabica* has in this way been made to yield not less than fourteen such varieties, and I am inclined to think that the Doddengooda so-called hybrid is not a hybrid at all but a variety of this nature.

That the best way to improve the strain of South Indian coffee lies along lines of hybridization and selection, I am convinced. The President of the Botanical Section of the British Association in his opening address at the last meeting of that body which was held, said : " The improvement of the plant from an economic point of view implies the co-operation of the botanist and the plant-breeder. The student of experimental genetics by directing his work to plants of economic value is able, with the help of the resources of agriculture and horticulture, to produce forms of greater economic value, kinds best suited to different localities and ranges of climate, those most immune to disease, and of the highest food value. Let the practical men formulate the ideal and then let the scientist be invited to supply it. Much valuable work has been done on these

lines, but there is still plenty of scope for the organized Mendelian study of plants of economic importance."

The production of new varieties of any crop is a sure method of increasing the yield. Soil conditions are only capable of being modified to a certain very limited extent, and if the plant-breeder and agricultural chemist can co-operate to produce a new type of plant better adapted to the local conditions it is obvious that an increase in crop will result.

At Dubarri, Mr. A. H. Jackson has produced a type of coffee plant which is fertile and comes true to seed, and the consequence is that the seed can be depended upon to provide nurseries for new clearings and new estates. This type is a true hybrid and a vigorous healthy type of *arabica* coffee, apparently disease-resistant to a high degree, and one which comes into bearing early and which gives a high yield of a good sample.

The result may be judged from the fact that some of the hybrid trees planted in a clearing purposely placed under adverse conditions of soils, shade, and facing, bore in their second year at the rate of 13¾ cwt. an acre, and more in some cases, and that they held and ripened this crop without shedding any primaries. They have now given three big crops without any sign of dying back. A sample of the bean has been very favourably reported on in England and the experiment has so far proved a great success.

Last September the final step in this experiment was begun, namely, the planting out of this hybrid on an estate scale. Last week I had the pleasure of inspecting the first clearing of this hybrid, at Malamby, some 23 acres in extent. It is planted in good soil and under ordinary estate conditions, and the clearing is an object-lesson in what a vigorous strain of coffee will do. Though only just a year old the large majority of the trees are three feet six inches in height and have 13 and 14 pairs of primaes closely set together. The plants are very healthy and are growing vigorously, and there were no failures from drought. The plants will have to be topped when less than 18 months out and will bear a crop in their second year and a good crop too, surely a record for *arabica* coffee.

The type is very even indeed, the plants in the row being as like as peas in a pod. In fact there is less difference to be seen between plant and plant than in an ordinary *arabica* clearing. There is little to show that the plant is a hybrid except its remarkably vigorous growth and a slight crinkle to the leaf.

This long experiment of Mr. Jackson's has now reached the last stage. It only remains to send home a shipment of the coffee from this plant and let it stand the test of competition in the open market with other South Indian coffees of good mark. This test is looked forward to with the utmost confidence, and I would once more impress upon doubters that they should visit Malamby and see for themselves what seed selection and hybridization of coffee can result in.

THE PROMOTION OF SCIENTIFIC AGRICULTURE.*

WHEN, in his recent speech at Wolverhampton, the Prime Minister spoke of the need for promoting scientific agriculture, he touched upon a subject of great national importance, and it may be profitable to attempt to give significance to his words. As was pointed out in the last issue of *Nature*, it may be that what Mr. Lloyd George had in mind was merely the extended use of artificial manures, the discovery and methods of use of which were undoubtedly scientific discoveries of the first magnitude, with which the name of Lawes and his experimental station at Rothamsted will ever be honourably associated. But we should like to think that the passages in the speech to which attention was directed are evidence that the Prime Minister has advanced to a position which few of his political forbears ever reached, namely, that progress in the arts and industries is indissolubly bound up with the progress of science; and science in this connection should not be limited to the "natural" sciences. The application of the scientific method to technical problems may well be as potent an element in progress as the adoption of the results of scientific research properly so-called. The field experiment in agriculture may not be research, but it is futile as an *experiment* unless it is conducted under the conditions and interpreted with the precautions which science dictates.

If, then, the Prime Minister has resolved that agriculture shall benefit from science, his first task is to take such measures as are likely to be fruitful of results. It will not suffice merely to provide unlimited funds even on the scale of a "day's cost of the war," if at the same time a well-considered plan of operations has not been framed. Scientific research in agriculture in the past has suffered

* Reprinted from *Nature*, dated 5th December, 1918.

from a failure to attract a sufficient number of men of first-class scientific talent. This failure has been largely due to the fact that agricultural research offered no career. Not only were such posts as were available inadequately paid, but essential needs, such as well-equipped laboratories with adequate provision for maintenance, had not been provided.

In the forefront, therefore, of the measures that should be taken to link together practical agriculture and science should be placed the recruitment of the best scientific talent that the country can provide, and this can be secured only by providing suitable opening with reasonable prospects of advancement for the best of the graduates in science turned out annually by the universities. Programmes of research avail nothing in the absence of competent men to carry them out. We should like to see a scheme inaugurated under which promising graduates in science would be attracted to the study of the agricultural sciences by the provision of special fellowships under a guarantee that a certain number would eventually be selected for permanent posts carrying adequate salaries.

It is true that in the past most of the great discoveries have been made by men actuated merely by a love of knowledge for its own sake, and no doubt the future will not differ from the past in this respect; but the real point is that, if anything is to be accomplished by State action, an appeal must be made to the motives by which the majority of men are actuated in choosing their life career. There can be no question that if emoluments were placed upon a basis which would enable workers to live in reasonable comfort, while prospects of advancement were also improved, the fruits of the vineyard would be ample. Agriculture and horticulture are still in the main ruled by empiricism and tradition, and while it is true that many of the more recent advances in science go to confirm the wisdom of the ancients, no one can doubt that we are still far from possible ends in many directions. Scientific methods of plant-breeding alone are capable of indefinite expansion. Scientific methods of controlling plant diseases can be foreshadowed with considerable confidence. The crop-bearing capacity of the soil may, as Mr. Lloyd George suggested, be increased by scientific

means, and in the region of diseases of live-stock the possibilities of progress have scarcely been explored.

The Prime Minister's declaration should not be forgotten. If agriculturists are alive to their interests, they will see that it is not allowed to lapse into the oblivion which so ruthlessly overwhelms many of the platform promises of politicians.

PLANT GROWTH AND REPRODUCTION.*

It is well known that in many plants there is a well-marked antagonism between growth and reproduction. This is clearly seen in the case of many fruit trees where the conditions which lead to active vegetative growth may be inimical to the reproductive processes. In such cases the reduction of vegetative growth, as by root pruning, may bring about vigorous flower and fruit production. The study of the effect of external conditions on these two processes, growth and reproduction, is obviously of great importance. In the case of the higher plants, however, the difficulty of investigating such a problem is increased by the close connection under ordinary conditions of the various external factors ; it is thus very difficult to alter one factor without altering others at the same time. In the case of algæ and fungi which can be grown in the laboratory under artificial conditions that can be easily varied at will, the difficulties are not so great, and it is not surprising that in this field of work our knowledge is mostly based on experiments with the lower organisms. The art of growing micro-organisms, such as bacteria, fungi and also algæ, in pure culture, has been carried to a high pitch of perfection, but since the growth of bacteria and fungi takes place within such wide limits and under a wide range of conditions, the analytic study of environmental factors has been largely neglected in the development of pure-culture methods. Some bacterial parasites of animals are markedly sensitive to temperature conditions, but the majority of fungi will grow within a wide range of temperature, so the effect of temperature on the growth of fungi has not been fully studied. Again it is convenient in culture-work to grow fungi in tubes plugged with cotton-wool, *i.e.*, under conditions in which gaseous exchange must be reduced to a low

* Reproduced from *Scientific American Supplement*, No. 2246, dated 18th January, 1919.

level. Yet, since most fungi tolerate readily such conditions, the effect of aeration on the growth of fungi has been neglected. A certain amount of analytic work with the help of synthetic media was carried out by earlier workers, such as Pasteur and Raulin, and later by Winogradsky and Beijerinck. In 1896 Klebs published the first of his series of papers on the effect of external conditions on algæ and fungi grown in pure culture. Klebs did not confine himself to the effect of such conditions on growth, but he studied the effect of external conditions on reproduction also. Klebs put forward the view that growth and reproduction are processes which depend upon different conditions, and that as long as the conditions favourable for growth are present, reproduction in the lower organisms does not occur. Klebs brought out also a point of great importance, that the conditions suitable for reproduction are more restricted than those for growth, so that reproduction is liable to be inhibited by too high or too low intensity of some factor.

It is well known to mycologists and plant pathologists that though there is little difficulty in growing most fungi in pure culture, the production of reproductive organs by fungi under these conditions is quite another matter. Anything which will enable one to control the reproductive processes of such fungi is thus not only of great physiological interest, but of considerable practical importance in plant pathology. Reference may thus be made in this article to a valuable paper—not of most recent date, but very generally overlooked—by G. H. Coons on the factors involved in the growth and pycnidium formation of *Plenodomus fuscomaculans* ("Journ. Agric. Research," V, 713–769, 1916), in which the relation of growth and reproduction to external conditions is very carefully studied. The fungus in question is one of the Sphæropsidaceæ and is parasitic on the apple.

It was found that in agreement with the dictum of Klebs there was a wider range of conditions suitable for growth than for reproduction. A small amount of growth will take place in conductivity water (sp. cond. 2×10^6) in vessels of resistance glass. Such a growth is certainly very surprising. The number of spores used for

inoculation was not more than fifty, so the growth observed could not be explained by transference of organic material from the spores. The salts required for development under these conditions, and in ordinary distilled water, were no doubt obtained from the glass, but the source of nitrogen, and especially of carbon, is obscure ; there is the possibility, first suggested by Elfving, that volatile substances may be absorbed from the laboratory air. It is interesting to note that while in conductivity water there was a just perceptible growth, in ordinary distilled water the growth was not only better, but a few pycnidia were actually produced. Under the conditions of experiment conductivity water is the lower limit for growth, but "distilled water" the limit for reproduction. As Coons points out, the sensitiveness to extremely small quantities of salts renders the problem of determining the necessary elements for this fungus almost insoluble with our present technique.

Up to a certain limit, possibly up to M-50, increase in concentration of the food supply increases reproduction ; after that point increase of food supply retards and finally inhibits reproduction. The organism was found to be sensitive to the reaction of the medium. and the different effect of different media was largely due to the reaction of medium not only at the start, but in later stages of growth. Many media, while having a favourable reaction at start, showed an unfavourable reaction later, with corresponding checking of growth. It was found that while growth can take place between the acid and alkali limits of +30 and − 10 to phenolphthalein, yet reproduction is stopped by a reaction only slightly on the acid side of neutrality. Maize broth is a much better substratum than oat broth, but if the latter be acidified with an acid phosphate, or even hydrochloric acid, it becomes almost as good a medium as maize. The various laboratory media are rightly condemned as "rather purposeless, clumsy devices in which this organism is overfed." Progress can only be made by the use of synthetic media, and a large number of experiments were made with a medium containing in various proportions potassium dihydrogen phosphate, magnesium sulphate, maltose and asparagin. A solution containing these four substances in concentrations of M-100, M-500, M-100, M-500, respectively, was found

to be an almost ideal culture medium for the growth and reproduction of this fungus; the pycnidium production was far higher than in any other medium. In this synthetic medium the inhibition of reproduction as a result of increasing or decreasing the carbohydrate or asparagin was very marked.

Light was found to be essential for reproduction though not for growth. The light need not be continuous, for a short exposure to strong diffuse light of cultures which are ready to produce pycnidia will allow, for a time, the production of these bodies in the dark. Abundant aeration was found to be essential, while transpiration was found to be a factor of only secondary importance.

The extremely interesting and important observation was made that the *stimulus of light could be replaced by a few drops of hydrogen peroxide.* This observation was extended, and it was shown that a number of other oxidizing agents, such as nitric acid, potassium permanganate, ferric chloride, would produce the same effect and cause the production of pycnidia in the dark. The view is put forward that among the parts of an organism there exists a strong competition for oxygen, and that under conditions which favour growth the available oxygen is all used for ordinary metabolic processes. If the food supply is reduced, as by transfer to media of lower concentrations or to distilled water, a "hunger-state" sets in and ordinary respiration is lowered. If the organism is now stimulated by light or by some oxidizing agent, oxidation of the richer cell materials, such as fat and protein, sets in, and a large amount of energy is set free. "This energy is used in re-shaping the reserve stuffs into complex protein bodies, the spores."—By Prof. V. H. Blackman, Sc.D., F.R.S., Imperial College of Science and Technology, London (Plant Physiology Committee), in "Science Progress."

SEEDLING SUGARCANES.*

In his presidential address to the Royal Agricultural and Commercial Society of British Guiana, Professor J. B. Harrison, C.M.G., M.A., discussed the general outlook as regards seedling sugarcanes, with especial reference to their stability, and the manner in which their production is best undertaken. These remarks, embodying as they do the experience of one of the principal workers in this field of enquiry, extending over the whole period since the simultaneous discovery in the West Indies and in Java of the seminal fertility of the sugarcane, carry very great weight; they are accordingly here reproduced in order to extend the publicity given to them. Professor Harrison said: —

" In 1897 investigators generally were of the opinion that once a new variety of sugarcane was produced, that after its first period of excessive vegetative vigour had passed, its characteristics were fixed for all time. Soon after the cultivation of the new varieties had been extended over large areas, it became painfully evident to the majority of planters that their characteristics are not fixed, and that in many instances, characteristics which in the earlier years promised to make a variety of sugarcane of high value both in field and factory, were the first to fail. This tendency towards senile degeneration renders it necessary to raise new varieties of seedling canes year after year, in the hope of having fairly good varieties available to replace others which may gradually fail.

" Experience has proved to us that it is very easy indeed to raise new varieties of sugarcanes which are of high promise as plant canes. It has further proved to us that it is relatively difficult to obtain sugarcanes capable of producing good crops as plant canes and as first ratoons; and that it is exceedingly difficult to produce

* Reprinted from *Agricultural News*, dated 21st September, 1918.

varieties which can be relied on to give satisfactory crops of plant canes, first, second, and third ratoons. Few indeed of the enormous numbers of new varieties which are now raised each year in various parts of the tropics will do this, and the problem of getting good varieties for cultivation under the long-ratooning system necessitated here by our deficient labour-supply and dependence on hand, instead of on mechanical, cultivation, becomes an exceedingly difficult one. Elsewhere, with the exception of Cuba, sugarcanes are as a rule only cultivated as plants, or as plants and first ratoons. Hence as the best varieties raised in Barbados, Java, and Hawaii have been chosen for their suitability for short ratooning periods, it is rarely that a sugarcane suitable for our long-ratooning conditions can be imported from elsewhere.

"The most successful method we have tried here for raising new varieties of sugarcane of promise is based on the facts that a sugarcane for successful cultivation on our heavy clay soils must be of well-marked vegetative vigour, and that whilst the range of variation in the saccharine-content of seedling sugarcanes is very great, its relative sugar-content is a fairly fixed characteristic of any variety. We endeavour to raise as many seedlings as we can from varieties of proved vegetative vigour, and select from them those having both well-marked vegetative vigour and relatively high saccharine-content. By this method we raised from D.625 the seedlings D.118 and D.419, the areas under which have increased from 2 acres and 1 acre, respectively, for the crop of 1911-12, to 2,710 and 1,360 acres, respectively, for this year's reaping.

"We have been advised time after time to give up our proven methods and to confine our efforts towards raising canes by cross-fertilization. If we had in this colony sugarcanes of single parentage showing fixed characters and, through their purity of origin, having little or no tendency to mutation or sporting, that advice would be excellent. In India, and to a less extent in Java, sugarcane varieties of high purity of strain exist; and with these it is possible that by the application of Mendelian principles in raising seedlings, new varieties of high value may be obtained. Up to the present, however, this has not taken place.

"At the inception of the sugarcane breeding work here, Jenman was enthusiastic over the possibilities of raising new varieties of high promise by controlled methods of cross-fertilization, but in 1892-93 our hopes in that direction received a severe shock. Using a variety of sugarcane, the Kara-kara-wa cane, which our experience in three preceding years had shown to produce seedling canes having usually somewhat close resemblance to the parent variety, and placing it under conditions by which it was impossible for its arrow or flowering shoot to be either cross-fertilized by any other variety, or fertilized by any other flower shoot of its own kind, we got seedling canes from the one arrow of 267 different sorts. The parent cane in its own seedling stage was hence possibly derived from fourteen diverse ancestral strains.

"Supposing, for example, that we take two kinds of sugarcane, one, X, having as ancestral kinds the varieties A,B,C,D,E and F, and the other, Y, derived from its ancestors A,B,G,H,I and J, it is evident that 406 different combinations can arise from the interbreeding of the two kinds, instead of a single blend or cross, X × Y.

"By Mendelian segregation, the inheritable properties of this diverse progeny will fall into three groups. We do not know which properties are inherited; but assuming that the general characteristics as a whole are heritable, the segregation of the seedlings from the cross X and Y may give rise in the first generation to 1,218 *groups* of varieties.

"Now either X or Y, by interbreeding with its own kind, could produce only 15 × 3 groups or forty-five general strains of sugarcanes. The complexity introduced by the cross-fertilization of existent complex hybrids is well illustrated by this example.

"Up to 1902 we had not made any systematic attempt at raising canes of controlled parentage. We now do it as a matter of regular routine—not with any idea of getting seedlings having definite and desired characteristics, but as a means of greatly widening the range of their variation. We have complete proof of the success of the method in this line. Unfortunately, there is no chance in British Guiana of controlled cross-fertilization of the sugarcane proving

a short and certain way to success in the production of new varieties of high saccharine value.

" Probably a more disappointing investigation has never been pursued than has been the search for improved varieties of sugar-cane. There are now many stations at work at it in the tropics and sub-tropics, their results appear to be very similar, in the earlier years, working with natural varieties of sugarcane, several kinds of high promise are almost invariably obtained ; in later years, when the mass of material for parental purposes has rapidly and enormously increased, the production of really good varieties appears to become increasingly difficult, and results satisfactory to both investigator and planter tend to be few and far between. It looks as though the good results arose from the unravelling of the complex ancestry of the natural varieties, whilst similar results from the retangling of the new strains thus obtained are comparatively rare, and are very elusive."

Those who are interested in the introduction of new seedling canes into their fields will, doubtless, in the light of these remarks, carefully consider the results which they are obtaining from their efforts. It will be observed that, in Professor Harrison's view, the work of finding promising seedlings is much more difficult when it is required to have canes that will ratoon well ; when plant canes only are grown, the problem is relatively simple.

The question of the stability of seedling canes propagated by cuttings has long been under investigation. Some have held that these canes would prove stable, and indeed in the early days of the work this was the commonly accepted view : now, however, many are doubting this, and Professor Harrison appears to be amongst those who are convinced of the tendency towards early senile degeneracy on the part of these seedlings. It is observed that, in some districts where sugarcane is cultivated, there is a tendency to substitute one new seedling after another in the hope of obtaining ever-increasing yields. Where adequate records exist, it would be well to examine these carefully, in order to see whether the newly introduced varieties retain their productiveness in full degree, or whether they fall off, so that the substitution of successive new varieties merely

serves to maintain the sugar production at a high level, but does not tend to raise that level to the extent that is hoped and desired. Now that it is the commonly accepted practice on the majority of West Indian sugar estates to weigh the canes which are delivered to the large factories, and seeing that in the factories continuous analyses are made of the juice obtained from these canes, there should be in existence some data whereby it may be possible to learn something definite concerning the stability or otherwise of seedling canes during the years subsequent to their introduction into cultivation on a large scale.

Still the fact remains that the continued production of new seedling canes is a matter of moment for the sugar industry. This work affords means of combating many of the forms of fungus disease to which sugarcanes are liable, and it also affords the means of maintaining the level of production, even if it does not tend to raise that level so rapidly as was at one time hoped might be the case. It is therefore work essential for the well-being and development of the industry, and should be carried on continuously.

THE CONSERVATION OF OUR CEREAL RESERVES.*

THE dangers to which grain stored under ordinary conditions is exposed may be classified under four heads :—(1) the attacks of rats and mice, (2) those of insects and mites, (3) those of moulds and bacteria, and (4) the process known as " heating." The amount of damage due to rats and mice is, no doubt, enormous, but might be avoided by any rational system of storage, and is a matter for legislation rather than for scientific investigation. The chief insect pests in this country are the two grain-weevils, *Calandra granaria* and *C. oryzæ*, while in India two other beetles, *Rhizopertha dominica* and *Trogoderma khapra*, are also responsible for much direct injury. Experiments on the rate of multiplication of the weevils show that at suitable temperatures they breed all the year round, but in this country normally only in the warmer months. At about 28°C. a single pair of rice-weevils increased about seven-hundredfold in four months. The accumulated excrement of the weevils attracts moisture and promotes decomposition, accompanied by the evolution of large quantities of ammonia, and in this way the destruction commenced by the ravages of the insects is completed. The process of heating is the result of enzymic action in the wheat itself, sometimes inaccurately spoken of as respiration, though fermentation would be a better term, which increases with rise of temperature (up to about 55°C.) and moisture content (Baily and Gurjar). In the eyes of the trade, heating appears to be a much more serious danger than weevilling. It is at present avoided by abundant ventilation, the grain being turned over as soon as the temperature becomes dangerously high, so as to cool it and carry off moisture.

* Abstract of a lecture delivered at King's College, London, on March 12, under the auspices of the Imperial Studies Committee of the University of London, by Prof. Arthur Dendy, F.R.S., reprinted from *Nature*, dated 20th March, 1919.

As an effectual means of preventing damage from all these sources, air-tight storage should be resorted to. Unfortunately, however, considerable doubt has been thrown on the efficacy of this ancient method by a widespread belief in the ability of weevils to withstand such treatment. This belief rests entirely upon inaccurate observations. Thus we find that tins which are supposed to be hermetically sealed, and look perfectly sound, are often leaky, as can easily be shown by placing them in hot water, when air bubbles out. Numerous experiments made at King's College by the lecturer and his colleague, Mr. H. D. Elkington, who is responsible more especially for the chemical analyses, prove conclusively that all insects present are more or less rapidly destroyed when weevilly wheat is sealed up in air-tight receptacles which it nearly fills. This method of treatment destroys the weevils in all their stages, and is also fatal at any rate to adult mites. The same treatment also prevents the growth of moulds and the process of heating. Two Dewar flasks, filled with grain having a moisture content of 20·7 per cent., were incubated at about 28°C. One was merely plugged with cotton-wool and the other hermetically sealed. In the former the temperature gradually rose to 49·4°C., while in the latter it remained almost stationary. The life of insects and moulds and the process of heating alike depend upon the supply of oxygen, and where this is cut off, no damage from these sources need be feared.

It has been demonstrated experimentally, not only that weevils require an abundant supply of oxygen, but also that carbon dioxide, if present in sufficient quantity, has a directly poisonous action upon them. In pure, moist carbon dioxide they become motionless in three minutes, and can remain in this condition for as much as four days (at room temperature) without losing the power of recovery. A mixture of carbon dioxide with 20 per cent. of oxygen is far more fatal than pure carbon dioxide. This is probably because, in the absence of oxygen, their metabolism is more or less completely suspended, so that the carbon dioxide is unable to exercise its poisonous effect. In a mixture of 56·4 per cent. nitrogen, 20·36 per cent. oxygen, and 23·22 per cent. carbon dioxide weevils became motionless in forty-three hours (at about 30°C.), and after ninety-one hours'

exposure, though 19·09 per cent. of oxygen still remained, none revived when supplied with ordinary air.

When wheat is sealed up in a normal temperature, carbon dioxide accumulates naturally owing to the so-called respiration of the grain, the rate of accumulation depending upon temperature and moisture conditions. At ordinary room temperature (July to October) in three months 300 grammes of English wheat, having a natural moisture content of 15·9 per cent., gave off 58·6 milligrams of carbon dioxide, sufficient to raise the percentage of that gas in the air in the receptacle (which was nearly filled with wheat) to 18·13. If insects be also present, the carbon dioxide accumulates more rapidly owing to the large amount which they themselves give off. It thus appears that in hermetically sealed granaries completely filled with grain there should be no need for any artificial addition of carbon dioxide such as has sometimes been recommended, and indeed, actually made, for the purpose of destroying weevils. Under proper conditions, which ought to be experimentally determined on a large scale, the grain must become self-protective as regards weevilling, mildew, and heating, to say nothing of rats and mice. Any damage which might arise while the carbon dioxide was accumulating would probably be negligible.

The construction of air-tight granaries or silos is a problem for the engineer, but there seems to be no insuperable difficulty in the way. If such granaries existed in the large wheat-growing countries, the grain might be completely sterilized as regards insect-life by storing for a suitable period before shipment, and the very serious weevilling which often takes place on board ship might be avoided. Moreover, it would be possible to equalize shipments all the year round and avoid the rush to get the grain away after harvest. Air-tight storage would also, in all probability, afford by far the best means of maintaining reserves of grain to meet emergencies such as war and failure of crops.

Further details have been, and will be, published in the reports of the Grain Pests (War) Committee of the Royal Society, under the auspices of which these investigations have been carried out.

THE ENZYMES OF SOME TROPICAL PLANTS.*

BY

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THE scriptural assertion that "man lives not by bread alone" has more than one meaning. Chemists are adding new shades of meaning to it daily through their investigations of the conditions of growth, ripening and vital processes of plants, and their study of the nutrition processes of man and other animals. The simple synthetic food-tablet, which was to carry the necessary food elements—protein, fat and carbohydrates—in the relative proportions demanded by the human body for its growth and development and the performance of its daily duties, now appears to be the dream of a pseudo-scientist. The process of assimilating our daily bread is a much more complex process than was once believed, and the perfect food of the future will hardly be prepared in tablet form. Scientists are beginning to investigate this phase of chemistry and nutrition, and we find such maladies as beriberi, scurvy, and pellagra being attributed to the consumption of a diet deficient in some particular ingredient which has heretofore escaped our notice because of the crude methods used in the examinations of these foods. Doubtless other dread diseases will be found to arise from similar causes or can be controlled by the use of proper food-stuffs.

An interesting part of this field of chemistry, called biological chemistry, pertains to the study of the enzymes and their properties. Much is known regarding enzymes, but much is still to be discovered regarding their functions in the plant's growth and their effect on assimilation processes when taken into the human body along with

* Reprinted from *Tropical Life*, vol. XIV, no. 4.

food. Owing to the uncertainty as to the purity of the separated enzyme, and the impossibility of determining any changes which have taken place in its composition during our attempts to isolate it, the study is very difficult. Thus in many cases we cannot say, when we have finished our study, whether we are dealing with but one compound or several compounds which have defied our attempts at separation; whether we have the compound with which we started, or one formed by a decomposition of the original one due to our attempts at purification. So one learns that the term enzyme is rather general even from this point of view, and when he considers the newness of the subject he can readily realize that many discrepancies have crept in due to faulty procedure on the part of the investigators.

Some of the foods we are accustomed to having served on the table uncooked contain enzymes of various kinds and in different quantities. An interesting speculation is: what influence do these have on the assimilation of the meal at which they are eaten? I shall confine this discussion to a consideration of some of the plants grown in the Tropics. For example, Chittenden[1] has investigated the pineapple and studied the proteolytic enzyme present in it. He called this enzyme bromelin, from the name of the family to which the pineapple belongs. Bromelin is rather resistant to heat, its activity is not destroyed by heating to 70° C., it digests egg albumen and blood fibrin, forming the same products as are formed by the action of trypsin. A rennet-like ferment is associated with bromelin. Instead of purchasing pepsin, which in many cases is worthless because of faulty preparation, it would be more profitable and agreeable to purchase pineapples.

Many persons are acquainted with the proteolytic enzyme which comes from the pawpaw and papaya,[2] and which is sold under the caption, papain. Those who have never eaten the papaya fruit are unfortunate. It has all the virtues of the drug, and besides is a delicious fruit. Probably the proportion of worthless papain on the market is even greater than that of pepsin, since the former

[1] *Journal of Physiology* (1894), XV, p. 249; and Caldwell, *Bos. Gaz.* (1905), XXXIX, p. 407.
[2] Pratt, D. S. *Philippine Journal of Science*, Sec. A (1915), X, p. 1.

is very largely prepared by men who do not understand the necessity of precaution in drying and packing. Then, too, the pharmaceutical supply houses demand a light-coloured product, basing their valuation partly on this property, and this leads to the preparation of an inactive product or the adulteration of the active substance, or both. The drying temperature must not be high if the papain is to retain its digestive activity, but since prolonged drying causes a darkened product much papain is dried at a high temperature in order to avoid a change in colour, and is therefore absolutely worthless. If the product is dried properly and is darkened in the process, the producer often resort to adulterating it with starch to lighten the colour. It is apparent that the buyers should modify their standards, and should purchase papain on the basis of its physiological activity. Papain is considered by Euler[1] to be identical with, or at least to resemble, bromelin very closely.

The banana has recently been thoroughly investigated by Bailey[2] for enzymes. This fruit is rich in ferments, giving evidence of the presence of a diastase, an invertase, a protease of the erepsin type, a lipase, while a peroxidase was found at all the stages of ripeness investigated. Thus the banana carries with it enzymes which influence the digestion of starch, sugar, proteins, and fats. In other words, the digestion of your cereal, the sugar which sweetens your cereal and your coffee, the protein of your egg, bacon and milk, and the fat of your egg, bacon and milk is added by the seemingly simple banana you have eaten for your breakfast.

The mango, another popular fruit of the Tropics, contains a proteolytic enzyme which has properties similar to those of bromelin. This investigation is just started by the Bureau of Science, consequently nothing further can be given regarding the identity of this protease with bromelin. But this brief survey of the prominent fruits of the Tropics, the pineapple, papaya, banana, and mango, convinces one that these fruits have a value other than that of nutrition, in that they aid in the digestion of other foods.

[1] Euler. "Pope-General Chemistry of the Enzymes." John Wiley and Sons, New York (1912), p. 39.

[2] *Journ. Amer. Chem. Soc.* (1912), XXXIV, p. 1706.

Considerable differences of opinion prevail among investigators in regard to the presence of a lipase in coconuts. De Kruff[1] and Lumia[2] report its presence in the germinating meat; Walker[3] of the Philippine Bureau of Science, on the other hand, was unable to establish its presence. Deming[4] believes that the lipase exists as a zymogen in the coconut which is activated by the addition of acids, as reported by Green[5] for the lipase existing in ricinus. If such an enzyme exists in coconut meat, it is not destroyed by heating, since meat that has been boiled for some time shows a similar increase in the acidity when the sample is incubated, as is shown by the uncooked meat. This contradicts the general belief regarding the destruction of enzymes by heating in the presence of moisture. However, Sohngen[6] has reported a lipase which he claims is not destroyed by fifteen minutes' boiling. One of the problems involved in the making of coconut oil and the drying of *copra* is the prevention of rancidity. Oils which have become rancid are difficult to make sweet, and Walker[7] states that these oils, after purification, again become rancid more readily than does the virgin oil. He has likewise demonstrated that moisture and oxygen are necessary for the development of rancidity. Lipase alone does not produce rancidity, since rancidity and acidity of oils are not synonymous, and lipase produces only the latter. The Bureau of Science has examined oils with high acid values, the rancidity of which was less than the rancidity of oils with a much smaller acid value.

While the rancidity of coconut oil cannot be attributed to the action of lipase, yet this enzyme splits the esters into glycerol and the constituent acids, and thus renders them in a condition to be more readily acted upon by any other agency. I believe two of

[1] *Bull. de Dept. de l' Agric. aux Indes-Neer* (1906), IV, p. 8.

[2] *Staz. Sperin. Agrar. Ital.* (1898), XXXI, p. 397.

[3] *Phil. Journ. Sci.*, Sec. A (1908), III, p. 111.

[4] *Phil. Agric. and For.* (1914), pp. 3–33.

[5] Green. "The Soluble Ferments and Fermentation," 2nd edition (1901), p. 244. (Cambridge University Press.)

[6] *Chem. Weekblad* (1911), VIII, p. 580.

[7] *Loc. cit.*

such agencies to be oxidase and peroxidase present in the meat. The action of these enzymes produces acid decomposition products, and these would give the rancid property to oils. It must be remembered that air and moisture are necessary to the production of rancidity in coconut oil, and that, even though the original oxidase and peroxidase have been destroyed by heating, any air allowed access to the oils carries with it mould spores. Impure oils will support mould growth. Dox[1] has demonstrated that these moulds produce all of the enzymes regardless of the character of the substrase, and in this manner rancidity might increase. Then, too, *copra* which has become extremely mouldy yields a more rancid oil[2] than clean, well-dried *copra*. This laboratory[3] has found that oils which have stood in closed bottles for periods of several months give tests for oxidases and peroxidases. That rancidity may be partly due, or in some cases initiated, by the action of oxidases and peroxidases is a plausible speculation.

One of the difficulties encountered in the investigation conducted by the Bureau of Science on the commercial possibility of making sugar from the juice of the nipa palm was due to the presence of a zymogen,[4] which, under atmospheric influence, causes the separation of white, flocculent invertase. The latter rapidly attacks the sucrose present. Invertase action could be inhibited by liming the receptacles for holding the juice, but even then the sugar content gradually decreased. A careful series of experiments proved that some enzyme capable of destroying both sucrose and invert sugar is present in the juice of the nipa palm. It was found that the nipa palm does elaborate a very active enzyme of the peroxidase type. The decreasing alkalinity indicated the formation of acid-decomposition products that combined with the lime, and eventually rendered the juice acid and reactivated the invertase. An interesting phase of this investigation was the discovery that only the shorter stalks, or those which have been tapped longest, elaborate this

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[1] *Plant World* (1912), XV, p. 40.

[2] The Bureau of Science is now investigating this phase of the rancidity of oils.

[3] Notes of an unpublished investigation now in progress.

[4] Gibbs. *Phil. Journ. Sci.*, Sec. A (1911), VI, p. 99. Pratt et al., *ibid.*, Sec. A (1913), VIII, p. 377.

peroxidase. This enzyme is readily destroyed by the addition of small amounts of sulphite to the lime cream used for coating the receptacles, and makes possible the commercial utilization of nipa juice for the preparation of sugar. The use of nipa juice for the manufacture of sugar gives another possible industry to the Tropics.

Enzyme action undoubtedly plays an important part in the curing of tobacco. Oosthuizen and Shedd[1] found invertase, diastase, emulsin and reductase present in appreciable amounts in the seed and leaf at all stages of growth, and also in the cured material. Lipase, inulase and a proteolytic enzyme were found in small amounts, while oxidases were found to decrease from the topping stage to maturity. It is absent in the cured leaf. Protein decreases, while amino-compound simultaneously appear and increase ; the starch is converted to sugar, and the sugar later disappears.

Growers of tobacco have learned from experience that certain methods of curing and handling are necessary to obtain good results. For example, in wilting the plant preparatory to placing it in the shed, too high a temperature must be avoided. Such a temperature destroys the efficacy of the enzymes and produces certain other deleterious effects. The phenomenon known as sweating, which takes place when tobacco is packed in bulk in moist air, is a result of enzyme activity and deserves more study from the bio-chemical standpoint, in order that the conditions may be more intelligently controlled.

I have found that cacao contains casease, protease, oxidase, raffinase, invertase and diastase during the various stages through which it passes in fermentation,[2] and believe that the product obtained from this fermentation is largely a result of the activity of these enzymes. Recently I have been able to demonstrate the presence of an emulsin in cacao which hydrolyses amygdalin.[3] I am satisfied that the organoleptic properties of fermented cacao are superior to those of the unfermented cacao made in this laboratory.

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[1] *Journ. Am. Chem. Soc.* (1913), XXXV, p. 1289.
[2] Brill. *Phil. Journ. Sci.*, Sec. A (1915), X, p. 123.
[3] Unpublished investigation.

Since these properties depend largely upon changes in the physical condition of certain constituents of the beans, on chemical changes which can be detected chemically only by very tedious operations, if at all, and upon the production of minute quantities of new compounds, their presence cannot be well demonstrated by chemical analyses. These differences in the quality of cacao are best recognized by an examination of its organoleptic properties.

The Bureau of Science has in progress an investigation on the seeds of the plants belonging to the family to which chaulmoogra belongs. These plants contain a cyanogenetic glucoside[1] in the seeds and other parts which is readily hydrolysed by emulsin, setting free hydrocyanic acid. A hydrolysing enzyme accompanies this glucoside in the plant, consequently when the seeds are bruised the glucoside is hydrolysed, and hydrocyanic acid escapes. The function of these constituents of the above-named plants is not definitely known, though various theories are held. Perhaps the most plausible theory is that the free hydrocyanic acid acts as an antiseptic agent when the plant is bruised, thus preventing further injury to the plant from bacterial action or fungus growth, but it is possible that this same factor has an influence on the efficacy of the chaulmoogra oil used in the treatment of leprosy. It is well known to those administering chaulmoogra oil to lepers that only the crude oil has any effect. This effect may possibly be due to the presence of the cyanogenetic glucoside in the oil, either alone or associated with the ferment and free hydrocyanic acid. This is one phase of the problem of the treatment by means of chaulmoogra oil that the Bureau of Science is at present investigating.

The rolling of tea breaks the cell walls of the leaves and releases the ferments. This process, " oxidation process," or " fermenting," Bamber[2] says, " is perhaps the most important in the whole manufacture, as both the quality and appearance of tea depend largely on the process being properly carried out."

[1] Power, et al. *Journ. Chem. Soc.* (1904), LXXXV, p. 838; *ibid.* (1905), LXXXVII, p. 884. De Jong. *Recueil des Travaux chimiques des Pays-Bas et de la Belgique* (1909), XXVIII, p 25; *ibid.* (1911), XXX, p. 220.

[2] " Tea Cultivation in Ceylon." Colombo: A. M. and J. Ferguson (1894), p. 39.

Coffee undoubtedly undergoes fermentation in both the dry and wet processes. An investigation of the nature of these fermentations should be made in order that the changes taking place may be understood. Control of these changes would undoubtedly result in a better quality of coffee.[1]

It is generally conceded[2] that the darkening of rubber is due to the action of an oxidase. Its action can be prevented by heating the rubber and thus destroying the enzyme, or by keeping the rubber from coming in contact with the air when being coagulated. When interviewed by the *Times* of Ceylon, Bamber[3] said: "It is advisable to ensure the destruction of the enzyme which occurs in the latex, together with certain organic products, which darken on expsosure to the air. The enzyme has an effect very similar to the enzyme in tea." The matter of enzymes and their effect on rubber, the use of inhibiting agents, etc., deserve further investigation.

In the article cited above, Armstrong is quoted as saying that no adequate sum of money has ever been appropriated for the investigation of rubber in the field. Such a state of affairs should be remedied without delay.

In conclusion, I wish to note that moulds elaborate all the known enzymes, and in many cases have considerable influence because of this property. Dox[4] has demonstrated the presence in moulds of protease, nuclease, amidase, lipase, emulsin, amylase, inulase, raffinase, sucrase, maltase, lactase, histozyme, catalase, and phytase, and has shown that these are formed regardless of the nature of the substrase. That the character of the substance has no influence on the type of enzyme formed is another evidence of the prodigal character of Nature and her preparedness for any emergency. This discovery throws light on the manner in which moulds do their works. The study of enzymes and their influence is just begun. We can look forward to many new and important discoveries in this field and more extensive generalizations.

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[1] See also what is said in our book, "The Fermentation of Cacao," Tropical Life Publishing Department, price 10s. net.

[2] Eaton, B. J. "The Preparation of Plantation Para Rubber," Department of Agriculture, Federated Malay States (1912), Bulletin 17.

[3] Tropical Life (1908), IV, p. 123.

[4] *Loc. cit.*

Notes.

MOTOR TRACTOR TRIAL AND DEMONSTRATION.

At the Pusa Farm, on Friday, 30th May, 1919, a trial and demonstration of the capabilities of the Fordson Motor Tractor was given by the Offg. Imperial Agriculturist, Mr. Wynne Sayer. The tractor was worked with a heavy two-furrow Ransom disc plough, a Ransom's spring tine cultivator, a Cambridge roller and a rake of three S.T. harrows. The trial was watched with great interest by a large crowd of planters, zemindars and officials. At the conclusion of the work on the land, the tractor was run up to the farm buildings and used to drive a Climax silage cutter. The greatest interest was evinced in the work done, as this is the first tractor of its type to be used in India. Experiments will now be started on the farm to determine working costs, etc. An account of the trial, with photographs, will appear in the next number of this *Journal*.

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AN ATTACK OF *NEPHANTIS SERINOPA* ON COCONUT PALM IN TRAVANCORE.

The attack of *Nephantis serinopa* on coconut palms in the Quilon town and the adjacent areas in Travancore was reported towards the end of May, 1918. On inquiry, it was found that the outbreak of this pest commenced nearly one year ago on a few palms in a churchyard, and that in the course of a year it attacked more than 9,000 palms.

Some *raiyats* thought that the drying of the leaves was due to the influence of small-pox, which was prevalent in a virulent form at that time; while others believed that it was due to the effect of smoke emanating from the tile factories of Quilon. The affected trees looked faded as if they suffered from the effect of severe drought, and the leaves, especially the matured ones, dried up. In extreme

Fig. 1. *Nephantis serinopa* in its larval, pupal and imago stages Natural size .

Fig. 2. A palm tree the affected leaves of which have been removed.

Fig. 3. The affected leaves showing the different stages of the attack.

Fig. 1. Palms damaged by *Nephantis serinopa*.

Fig. 2. A group of treated palm trees.

cases the palms died of the attack. In ordinary cases, the health as well as the yielding capacity of the palms was considerably reduced, and such palms took more than a year to regain their normal condition.

The insect completes its life-history on the foodplant itself. The eggs are found on the damaged leaves. The larva is not an open eater. It makes a gallery of silken and excrementitious matter on the lower surface of the pinnæ in such a way that one would be tempted to think that the larva is a leaf roller. That the damage done by *Nephantis serinopa* differs very much from that of the Limacodid larva, the attack of which on coconut palm was recorded towards the commencement of the year 1914, is clear from the fact that the latter eats away openly the leaf blade, leaving only the midrib of the pinnæ; whereas the *Nephantis serinopa* makes a gallery on the under-surface of the leaf and eats away only the green tissue of the leaf blade from within the gallery.

The full-grown larva measures a little more than 20 mm. in length. Pupation takes place on the damaged leaves of the food-plant. The larva can be seen throughout the year. The moth is attracted to light, but not so readily as *Schœnobius bipunctifer.*

The pest is new to Travancore. Spraying with contact and stomach poisons was done on young trees with some success. The process of cutting and burning the affected leaves has a decided effect in keeping the pest under check. This was recommended to the *raiyats* and they adopted it with success. More than 3,888 trees were treated, and nearly 24,248 leaves were cut and burned. When the *raiyats* were fully convinced of the efficacy of this treatment, they themselves carried out the work without much external pressure and the pest was completely brought under control.—[R. MADHVAN PILLAI.]

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PERENNIAL FORAGE SHRUBS.

IN a previous number of this Journal[1] appeared a short account of the trials of exotic drought-resisting plants in India from the pen

[1] *The Agricultural Journal of India*, vol. II, part II, 1907.

of Mr. (now Sir) Frank G. Sly in which he deprecated any further extensive trials of exotic plants except perhaps in arid tracts, such as Sind, Rajputana and the Western Punjab. The following note is, however, reproduced from the *Agricultural News*, Barbados, dated July 13, 1918, with the hope that some of the Provincial Departments of Agriculture in India interested in the question of drought-resisting plants will give a trial to the three plants which appear to be of good promise. It should be noted, however, that the first of these has already been tried in the United Provinces and failed to stand the heat.

" Experiments which are being made in the Botanic Garden, Sydney, as to the fodder value of three useful leguminous shrubs from Teneriffe, are noticed in the *Agricultural Gazette of New South Wales*, April, 1918. The first of these, *Cytisus proliferus*, is known in its native island as Tagasaste. This is stated to be a leafy shrub with a graceful drooping habit, which does well under dry conditions, and stands considerable variations in temperature from hot to cold. Its quick growth makes it useful as a wind-break, and if kept trimmed, it grows into a pleasing shrub from 8 to 15 feet high. For fodder purposes, it should never be allowed to grow into a small tree, but should be cut regularly at least twice a year; the foliage is then always young and soft, and in this state it is readily eaten by all kinds of stock. It is recommended as a safe and profitable stand-by in districts where droughts interfere with the cultivation of better fodder.

" The second shrub of the same genus is *C. stenopetalus*, called Gacia in Teneriffe. This makes a beautiful, sweet-scented, yellow-flowering shrub, not so large in growth as the Tagasaste, but just as robust, producing thick green foliage.

" The third of these shrubs, *C. pallidus*, is known as Gacia blanca, and is even more beautiful as a shrub than the Gacia, because of its charming silvery foliage, although both species bear the same yellow flowers.

" Both the Gacias make excellent fresh fodder and silo material if cut in the same way as the Tagasaste. The flowers also of both

of them yield large quantities of nectar, and are exceedingly useful to bee-keepers.

"Dr. G. V. Perez of Teneriffe is interested in having these three plants experimented with in various parts of the world, and would probably be glad to supply seeds for trial in any of the drier West Indies."

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THE following extracts from official reports dealing with the use of **cactus** in the Ahmednagar District **as a fodder substitute** have been published by the Bombay Government :—

Extract from a Report by Mr. E. Weston, I.C.S., Assistant Collector, Ahmednagar, dated 15*th March,* 1919.

CENTRAL camps were opened in January at Sheogaon and Newása. Cattle were taken from agriculturists willing to have their cattle fed upon cactus. Such cattle are kept in the camp for about one month at Government expense, and being accustomed to the diet are returned to their owners, who are given every facility and encouragement to continue using the fodder.

In the early stages we were dependent upon blow-lamps for burning off the cactus thorns. These proved unsatisfactory for village use, as they continually went wrong. At the end of January, blacksmith's forges were tried, and their satisfactory working has made it possible for villagers to prepare cactus cheaply and easily in their own villages.

The large blacksmith's forge is expensive, and it is difficult to obtain a large supply of them quickly. Equally good results are obtained by the use of small hand bellows. Arrangements have been made to obtain about 100 pairs of these.

Now that the technical difficulties in the way of preparing the fodder without elaborate apparatus are removed, it has become possible to expect villagers with a little encouragement and assistance to take up the idea themselves. The following is an account of work done with that purpose.

The central camps have been increased to four by establishing camps at Tásgaon and Páthardi. In these the cattle of agriculturists are admitted and fed for a month. The owners and others are

encouraged to visit the camps and learn the method of preparing. Mamlatdars use the camps as offices when hearing petitions from *tagai** applicants. On the road outside the camp a man is posted with a box of prepared cactus which he offers to cartmen or other passers-by willing to take it for their cattle. At Sheogaon we are now in a position to ask a price for such prepared cactus.

The progress made among the villagers is greatest in Sheogaon *taluká* and least in Páthardi *mahál.* Sheogaon is the area in which famine is most severe ; Páthardi that in which it is least so.

In Páthardi, no villages have gone in for cactus-feeding seriously. In Newása *taluká,* 27 villages are feeding about 450 cattle. Here the average number per village is small, and we are still in the experimental stage when villagers send their useless cattle to try the fodder before giving it to their working animals.

In Sheogaon, about 800 animals are being fed in 30 villages. Among these 30 villages there are several in which a further stage than the experimental has been reached. The following gives the number of animals fed in five of the most advanced villages :—

	Animals
Thakur Nimbgaon	150
Ghotan	75
Balam Takli	60
Dor Jalgaon	52
Avhane	35

In all these villages the work is managed by the villagers. They have been assisted by grants of hand bellows and pincers, and cotton seed and grass given on *tagai.*

The best example of village organization is the village Ghotan. The work is managed by a "Panch" of the leading inhabitants. The villagers have subscribed towards working expenses. Cactus is prepared morning and evening, and distributed to the owners of the cattle. Those in poor circumstances receive it free, and others pay from 2 to 4 annas per 100 pounds. The *talathi*† is keeping a register showing the animals fed and the amount of fodder distributed. The cactus is prepared by the village *lohar*‡ and his son, who are both

* Takavi. † Village accountant. ‡ Blacksmith.

remarkably skilful. Each receives six annas a day from the managing "Panch." The services of the members of the famine kitchen in the village are used for cleaning the burnt cactus. The chopping is done by the village *mahars.** The animals are in excellent condition, and the large proportion of them are working animals. I have every hope that similar organizations will be instituted in many more villages of Sheogaon and Newása *talukás.* If this is successful, prickly pear feeding in famine times will have become established.

I may mention as a proof of the growing belief in the fodder that the people of Ghotan, besides undertaking their own camp, have subscribed Rs. 150 towards the work of popularizing the use of prickly pear in Sheogaon *taluká.*

Extracts from a Report by Mr. C. A. Beyts, O.B.E., I.C.S., Collector of Ahmednagar, dated 28th March, 1919.

Mr. Weston's figures are now about three weeks old. There are now over 4,000 village cattle subsisting mainly on cactus.

* * * * *

The consumption of cactus in Newása and Sheogaon is already equivalent to about 12 lakhs of pounds of grass per mensem, and the value of the work done in these *talukás* can be judged from the fact that the supply of Government grass is practically exhausted already and that no more is required, though two months of the fodder famine remain in the best of circumstances.

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HOW TO AVOID INTERMITTENT BEARING OF FRUIT TREES.

In a recent article in *Country Life,* it is maintained that the intermittent bearing of fruit trees can be avoided by a proper system of manuring. The writer, H. Vendelmans, says that, in spite of a very common belief, it is certain that the bearing capacity of fruit trees is not limited to every other year. Ninety-one orchardists out of every hundred in England assert that a good crop is followed by a thin crop, and *vice versâ* ; but the regularity with which excellent returns are obtained annually from espalier trees, and trees under

* Butchers.

glass, which received different treatment from that meted out to orchard trees, ought to suggest some scepticism about the old tradition. In the case mentioned, it is possible to rely on good crops every year. Among the reasons which explain this more regular bearing, manure takes a first place. Without it, the abundant crop of one year makes so great a demand upon plant food that the reserves of the trees are exhausted, and are not strong enough to feed a new crop for the next year. Hence a poor return follows a good return. In the year following the bumper crop, the trees often carry no fruit at all, but they accumulate new reserves, and are then ready to feed a large crop the next year. When the exhaustion of the trees is prevented by appropriate manuring, bearing takes place much more regularly.

In manuring fruit trees, it is necessary to bear in mind that the blossom buds are formed the year before they come out, that is to say, during the period of bearing or shortly afterwards. Consequently, they are forming at a time when the trees are being exhausted, or have been exhausted. Therefore, a liberal supply of easily assimilable manure must be placed at their disposal during this period. Liquid manure, wood-ashes, basic slag, and lime should be used, taking into account that a superabundant supply of nitrogen might lead to a production of wood instead of flower buds, and that phosphates assist in developing the flavour of the fruit.

This serves to emphasize the essential use of manures in orchard cultivation, if the best results are to be attained.—[*The Agricultural News*, dated 5th October, 1918.]

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COTTON-SEED FLOUR FOR HUMAN CONSUMPTION.

Mr. Ed. C. de Segundo, in the course of his paper on "The Removal of the Residual Fibres from Cotton-seed and their Value for Non-textile Purposes" read before the Royal Society of Arts, said :—

A highly nutritious flour suitable for human consumption has been produced in large quantities in America during the war from the residue of the meats after the oil has been extracted. This flour,

which it is stated, has been recommended by the United States Government as a diluent for wheat, is being manufactured in large quantities in the United States. It is called "Allison" flour in honour of its originator, the late Colonel J. W. Allison, of Ennis, Texas. It contains about 50 per cent. of protein and 8 per cent. of fat, and is practically starch-free. Wheat flour, as is well known, shows on analysis about 11 per cent. of protein, about 2 per cent. of fat, and contains a high percentage of starch. The coefficient of digestibility of the protein in Allison flour is stated to be about 88 per cent., while that of the protein in wheat flour is about 94 per cent. Thus, the protein and fat content of cotton-seed flour is about five times that of wheat flour, and while, on this account, bread should not be made solely from cotton-seed flour (except under medical advice in cases where a starch-free diet is a necessity), cotton-seed flour is eminently suitable for mixing with wheat flour and potato flour. By the judicious use of cotton-seed flour a wholesome and palatable bread can be made, possessing the same nutritive properties as the all-wheat loaf, while effecting a considerable reduction in the actual quantity of wheat flour used. For example: A mixture of 5 per cent. cotton-seed flour, 10 per cent. potato flour, and 85 per cent. of wheat flour (percentages calculated on the weight of solids only), would produce a loaf containing a rather higher percentage of protein than that found in the all-wheat loaf of pre-war days. As the wheat consumption in this country was over 6,000,000 tons per annum, on the average, over a period of years immediately preceding the war—of which about 5,000,000 tons had to be imported—the possibility of effecting a saving of 15 per cent. of our normal requirements of wheat flour is a matter to which serious consideration might usefully be given. I have dealt at some length with the properties of cotton-seed flour in a paper read before the London Section of the Society of Chemical Industry on March 25th, 1918.—[*Journal of the Royal Society of Arts*, dated 14th February, 1919.]

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Vegetable-drying, which has reached such extraordinary development in Central Europe, is an emergency industry, and

Dr. Eisener has predicted its decline after the war. Before the war, however, in 1913-14, Germany dried 11,500,000 hundredweight of potatoes. The potato-drying capacity has been since increased to 37,000,000 hundredweight; and a recent census showed the drying plants of Germany to include 700 especially designed for potatoes, 150 for corn, 400 for cabbage, 400 for partly dessicating different products, 250 for various vegetables, and 22 for milk. Even kitchen refuse has been dried in some of the larger cities. Studies are said to be still in progress of the best methods of drying to retain original flavours, and experiments on the best ways of cooking have been made. The German demand has built up large drying establishments in Holland, where dried vegetables have been little used. One drier estimates that the processes now employed in Holland reduce the weight of root vegetables, including potatoes, about 80 or 85 per cent.; and of such vegetables as celery, cabbage, lettuce, etc., as much as 90 or 93 per cent.—[*Capital*, dated 28th March, 1919.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

WOODHOUSE-SOUTHERN MEMORIAL FUND.

	Rs.
DONATIONS received up to the 28th February, 1919, and acknowledged in the *Agricultural Journal of India*, Vol. XIV, Pt. II, April, 1919.	1,030
Donations received during the period from 1st March, 1919, to 31st May, 1919:—	
The Hon'ble Mr. C. A. H. Townsend, I.C.S. (S) ..	40
G. Milne, Esq.. I.C.S. (W)	100
A. McKerral, Esq.	50
D. Milne, Esq.	30
A. G. Birt, Esq.	30
A. A. Meggitt, Esq.	30
Bhimbhai M. Desai, Esq.	50
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D. Clouston, Esq.	50
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Capt. Roger Thomas	50
G. R. Hilson, Esq.	10
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W. S. Hamilton, Esq., I.C.S. (S)	50
L. C. B. Gloscock, Esq. (S)	10
Maulvi Fatehuddin (S)	20
Pandit Chandan Ram (S)	5
Malik Barkat Ali (S)	5
G. C. Sherrard, Esq.	50
H. M. Chibber, Esq.	15
TOTAL ..	Rs. 1,930

HIS MAJESTY THE KING-EMPEROR'S BIRTHDAY HONOURS LIST contains the following names which will be of interest to the Agricultural Department :—

K.C.I.E. THE HON'BLE MR. C. E. LOW, C.I.E., I.C.S., Secretary to the Government of India, Department of Commerce and Industry (sometime Director of Agriculture and Industries, Central Provinces and Berar).

C.S.I. THE HON'BLE MR. R. A. MANT, B.A., I.C.S., Offg. Member of the Council of the Governor-General of India, in charge of the Revenue and Agriculture Department.

C.I.E. MR. H. C. BARNES, M.A., I.C.S., Offg. Commissioner, Surma Valley and Hill Districts (sometime Director of Land Records and Agriculture, Eastern Bengal and Assam).

MR. H. CLAYTON, M.A., I.C.S., Offg. Commissioner of Settlements and Land Records, Burma (sometime Director of Agriculture, Burma).

MR. D. CLOUSTON, M.A., B.Sc., Offg. Director of Agriculture, Central Provinces and Berar.

C.I.E. (*War Services*). MR. C. A. INNES, I.C.S., Food Controller and Joint Secretary to the Government of India, Revenue and Agriculture Department.

C.B.E. MR. C. G. LEFTWICH, I.C.S., Controller of Civil Supplies, Central Provinces and Berar (sometime Director of Agriculture, Central Provinces and Berar).

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* *

THE HON'BLE SIR CLAUDE HILL, K.C.S.I., C.I.E., I.C.S., Member of the Council of the Governor-General of India, in charge of the Revenue and Agriculture Department, has been granted leave on medical certificate for a period of four months from 9th April, 1919.

THE HON'BLE MR. R. A. MANT, B.A., I.C.S., officiates for Sir Claude Hill, and Mr. J. Hullah, I.C.S., acts in place of Mr. Mant as

Secretary to the Government of India in the Revenue and Agriculture Department.

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Mr. J. Mackenna, C.I.E., M.A., I.C.S., Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, has been granted privilege leave for six months from the 13th April, 1919.

Mr. G. A. D. Stuart, B.A., I.C.S., has been appointed to officiate in place of Mr. Mackenna.

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Mr. G. S. Henderson, N.D.A., N.D.D., Imperial Agriculturist on deputation under the Indian Munitions Board as Controller, Agricultural Requirements (Mesopotamia), Poona, is granted privilege leave for three months from the date of his relief from the Munitions Board.

Mr. Wynne Sayer, B.A., will continue to act as Imperial Agriculturist, during the absence of Mr. G. S. Henderson on privilege leave.

***

Mr. R. Cecil Wood, M.A., Principal of the College of Agriculture, Professor of Agriculture and Superintendent of the Central Farm, Coimbatore, has been appointed to act as Director of Agriculture, Madras, during the absence of Mr. Stuart.

Mr. W. McRae, M.A., B.Sc., F.L.S., Government Mycologist, officiates as Principal of the College of Agriculture, Coimbatore, and Mr. Roger Thomas, B.Sc., Deputy Director of Agriculture, acts as Professor of Agriculture and Superintendent of the Central Farm, Coimbatore, *vice* Mr. Wood.

***

Dr. C. A. Barber, C.I.E., Government Sugarcane Expert, Madras, has been granted combined leave for six months from the 12th April, 1919, and has been permitted to retire from service on the expiry of the leave.

Mr. T. S. Venkataraman, B.A., Assistant Government Sugarcane Expert, Madras, has been appointed to act as Government Sugarcane Expert until further orders.

***

Mr. F. R. Parnell, B.Sc., Government Economic Botanist, Madras, has been granted combined leave for 12 months from 30th April, 1919.

Mr. G. N. Rangaswami Ayyangar, B.A., has been appointed to officiate for Mr. Parnell until further orders.

***

Mr. G. R. Hilson, B.Sc., Deputy Director of Agriculture, II & III Circles, Madras, has been granted combined leave for 13 months from 1st May, 1919.

***

Mr. K. T. Achaya, Assistant Director of Sericulture, Jammu, has been appointed temporarily as Sericultural Expert in the Agricultural Departmert, Madras.

***

Rao Bahadur K. Ranga Achariyar, M.A., Government Lecturing and Systematic Botanist, Coimbatore, was granted privilege leave for three weeks from 15th May, 1919.

Mr. C. Tadulingam Mudaliyar acted as Government Lecturing and Systematic Botanist, during Mr. Ranga Achariyar's absence.

***

Mr. T. V. Ramakrishna Ayyar, B.A., F.E.S., F.Z.S., Acting Government Entomologist, has been granted privilege leave for two months from or after 5th May, 1919.

Mr. Y. Ramachandra Rao, M.A., has been appointed to officiate as Government Entomologist, *vice* Mr. Ramakrishna Ayyar on leave or until further orders.

***

Mr. S. Milligan, M.A., B.Sc., Director of Agriculture, Bengal, has been allowed combined leave for seven months.

MR. R. S. FINLOW, B.Sc., F.I.C., Fibre Expert to the Government of Bengal, officiates as Director of Agriculture, Bengal, in addition to his own duties, during the absence of Mr. Milligan.

***

MR. H. E. ANNETT, B.Sc., F.C.S., Agricultural Chemist to the Government of Bengal, has been allowed combined leave for 19 months.

MR. G. P. HECTOR, M.A., Economic Botanist to the Government of Bengal, has been appointed to act as Agricultural Chemist, Bengal, in addition to his own duties, *vice* Mr. H. E. Annett on leave.

***

MR. A. D. MACGREGOR, of the Civil Veterinary Department, Bengal, has been allowed privilege leave for three months.

***

MR. H. M. CHIBBER, M.A., has been appointed Plant-Breeding Expert to the Government of Bombay, with effect from 1st January, 1919.

***

MR. T. F. MAIN, B.Sc., Deputy Director of Agriculture in Sind, has been granted combined leave for six months from 6th May, 1919.

MR. GUL MAHAMMAD ABDUR RAHMAN, Divisional Superintendent of Agriculture in Sind, acts for Mr. Main pending further orders.

***

MR. W. M. SCHUTTE, A.M.I.MECH.E., Agricultural Engineer to Government, Bombay, has been granted, with effect from 27th April, 1919, combined leave for six months.

MR. G. H. THISELTON DYER acts as Agricultural Engineer during Mr. Schutte's absence.

***

MR. G. C. SHERRARD, B.A., Deputy Director of Agriculture, Patna Circle, on his reversion from military duty, has been placed,

with effect from the 17th February, 1919, on special duty in connection with the closing of the Bankipore Agricultural Farm, and the establishment of the Ranchi Asylum Dairy, and the new Experiment and Seed Farms at Purulia and Ramgarh.

***

SUBJECT to confirmation by His Majesty's Secretary of State, the Government of India have sanctioned the re-employment of Mr. M. M. MacKenzie as Superintendent of the Sipaya Cattle-Breeding Station for a further period of five years.

***

MR. B. C. BURT, B.Sc., M.B.E., Deputy Director of Agriculture, Central Circle, United Provinces, has been granted privilege leave for six months, with effect from the 4th April, 1919.

RAI SAHIB NAND KISHORE SHARMA, Divisional Superintendent of Agriculture, Central Circle, Cawnpore, officiates in place of Mr. Burt.

***

MR. H. M. LEAKE, M. A., Economic Botanist to the Government of the United Provinces and Principal, Agricultural College, Cawnpore, has been granted combined leave for ten months, with effect from the 16th April, 1919.

MR. G. CLARKE, F.I.C., Agricultural Chemist to Government, United Provinces, officiates as Principal, Agricultural College, Cawnpore, *vice* Mr. Leake granted leave.

MR. W. YOUNGMAN, B.Sc., Assistant Economic Botanist to Government, United Provinces, officiates as Economic Botanist, *vice* Mr. Leake on leave.

***

MR. F. J. WARTH, M.Sc., B.Sc., Agricultural Chemist, Burma, has been granted combined leave for six months.

***

MR. T. RENNIE, M.R.C.V.S., Second Superintendent, Civil Veterinary Department, Burma, has been granted combined leave for six months.

SECOND-LIEUT. (T. LT.-COL.) R. J. D. GRAHAM, I.A.R.O., has been mentioned by Lt.-General W. R. Marshall, K.C.B., K.C.S.I., Commanding-in-Chief, Mesopotamia Expeditionary Force, in his despatch, dated 11th November, 1918, for distinguished and gallant services and devotion to duty.

***

THE services of Mr. G. Evans, M.A., Deputy Director of Agriculture, Central Provinces, have been placed temporarily at the disposal of the Government of Burma.

MR. J. H. RITCHIE, M.A., is appointed to act as Deputy Director of Agriculture, Northern Circle, Central Provinces, *vice* Mr. G. Evans.

***

MR. J. N. CHAKRABARTI, Superintendent of Agriculture, on deputation, has been appointed to officiate as Second Deputy Director of Agriculture, Assam, from the 16th May, 1919.

***

MR. J. G. CATTELL, M.R.C.V.S., Superintendent, Civil Veterinary Department, Sind, Baluchistan and Rajputana, has been granted combined leave for two years.

Reviews.

Soil Biology. Laboratory Manual.—By A. L. WHITING, PH.D., Assistant in Soil Biology in University of Illinois, College of Agriculture and Agricultural Experiment Station. Pp. ix+143. (New York: John Wiley & Sons; London: Chapman & Hall. Ltd.)

Extract from preface:—"The purpose of this Manual is to present the important principles of soil biology, particularly as they point to the intelligent control of the essential elements of plant food. The principles are incorporated in practices which acquaint the student with the various forms of life in the soil and their activity. . . . . Emphasis is laid upon quantitative results, and the measure applied consists of bio-chemical and chemical methods."

The small volume is divided into two parts.

Part I contains the practices referred to in the preface, a total of thirty-three, with numerous questions and references to recent literature. The subjects dealt with include soil plating, the nitrogen cycle, the sulphur cycle, fungi and algæ in soils and their relation to soil nitrogen, ærobic and anærobic decomposition of cellulose, protozoa in soils, enzymes, iron bacteria, decomposition of cyanamid, cross inoculation of legumes, and the solvent action of soil bacteria on minerals.

Part II contains clear and concise descriptions of the bacteriological, chemical, mechanical and pot culture methods applied in the Illinois laboratory, and a list of reagents, chemicals and apparatus for the teaching of soil biology.

The volume is a most useful addition to previous laboratory manuals.—[J. H. W.]

***

We welcome in pamphlet form the very interesting lecture on the subject of **Agricultural Organization in Bengal,** delivered on the 28th March, 1919, under the auspices of the Bengal Co-operative Organization Society, by Mr. G. S. Dutt, I.C.S., Collector of Birbhum. The three main propositions which he lays down are that agriculture is still the greatest industry in the country, that in the application of science to the practice of husbandry lies the path of advance, and that an agency for the dissemination of such knowledge can be created by the combined application of the principles of decentralization and co-operation. The first two are universally accepted. The main interest of Mr. Dutt's lecture lies in the account he gives of the system of Branch Agricultural Associations which have been constituted in the district of Birbhum for the purpose adumbrated in the third proposition. Provincial, Divisional, and District Agricultural Associations are, in this country, perhaps as old as the Agricultural Departments themselves and many have done useful work, but generally it may be said that the work is of a spasmodic character and carried on by individuals rather than by the association in its corporate capacity. This has been mainly due to the areas of their activities being too large and the associations containing too few practical agriculturists. To meet this difficulty, the Birbhum District Agricultural Association evolved a system of Branch Agricultural Associations of members residing within the area of a Police Thana. This proved so popular that even the area of a Thana is now considered too large for effective corporate work, and associations are being formed on a much smaller territorial basis. The number of such branch associations has, during four months, increased from 16 to 30. These branch associations in their present form, Mr. Dutt describes as "associations of farmers—large and small, literate and illiterate, *bhadralog* and peasant—for the purpose of mutual discussion and dissemination of information, for the joint purchase of seeds, manures and implements, and for adopting new varieties and improved methods of cultivation

recommended by the officers of the Agricultural Department." During the first year of their existence these bodies indented for new manures, seeds of superior varieties of paddy, wheat, groundnut and other crops, as well as improved varieties of sugarcane cuttings, etc., worth about Rs. 8,000. In the present year, the indents are expected to be about Rs. 14,000 in value. These are no mean figures for the first year's work in a backward small district. But these associations are not mere agencies for distribution of seeds and manures. "They provide a basis for practical combination of farmers with a view to the securing of important agricultural information and they constitute practical rural schools in which the members learn from each other's example the lessons of agricultural improvement." Moreover, when the full scope of their usefulness is developed, there will hardly be an agricultural problem in the solution of which these associations cannot play an important part. Mr. Dutt is of opinion, and we agree with him, that the organization of such bodies will most usefully supplement the activities of the Co-operative Department, and that without some such organization no scheme of rural reconstruction will have any chance of success. Agricultural development as well as expansion of the co-operative movement has, in every one of the most progressive countries in agriculture, been preceded and fostered by a system of farmers' associations in the villages on lines similar to the Birbhum system. Mr. Dutt therefore appeals to all public-spirited people in the other districts of Bengal to equip themselves with this healthy and natural system of rural and national reconstruction which is such a crying need in Bengal to-day. Government, he says, have ensured fair rent, fixity of tenure and free sale ; Government are providing the required expert officers and farms for research work ; and now the people themselves should take up the work of organization and combination and of untiring effort towards improvement through combined action. We hope Mr. Dutt's appeal, backed by the example of Birbhum, will not fall on deaf ears. [EDITOR.]

***

Agricultural Statistics of India, 1916-17, Vol. I.—This annual volume is the thirty-third of the series started in 1886, with

statistics for 1884-85, and has just been issued by the Department of Statistics, India. A map showing the departure from normal of the cropped area and of the rainfall in 1916-17, five charts showing total area cropped, food-crops area, cultivable area, irrigated area, fallows, etc., and three diagrams showing areas under different crops, live-stock, and shares of provinces in the total area under principal crops, introduced for the first time this year, have added considerably to the usefulness of the publication. The diagrams bring out a close correlation between the total rainfall and the area cropped.

The total area of India, including Burma, is 1,151,336,000 acres, and this volume deals with the 616,160,000 acres out of this which are in British India, excluding Indian States. After allowing for forests, buildings, water, roads, etc., we find that 63 per cent. of this total remains available for cultivation. The net area actually cropped in the year was, however, 229,709,000 acres, or 37 per cent. of the total area, as against 221,778,000 acres in the preceding year, or an increase of 3·6 per cent. The area under food-grains showed an increase of 5,340,000 acres or 2·6 per cent. as compared with the preceding year. Of oilseeds, sesamum, rape and mustard somewhat declined, but linseed and other oilseeds increased by 406,000 acres. Sugar showed an increase of 40,000 acres, while the increases under cotton and jute were 2,401,000 and 323,000 acres, respectively.

From the second map and the charts it can be deduced that the general increase in cropped area was mainly due to a rainfall well above the average, but no table of rainfall is given in the volume. We suggest that this might be included in future.

It is admitted that the figures in Table VI, which deals with transfers of land, are incomplete. Madras has discontinued the return since 1913-14, and we suggest that it would be best to omit the whole table in future. The publication of incomplete figures serves no useful purpose. The volume closes with two useful appendices giving lists of vernacular terms and names of crops. We notice some errors in these, *e.g.*, *Dividivi* is more used as a tanning stuff than a dye and *Kolinji* (*Tephrosia purpurea*) is a green

manure crop and not a drug; while the definitions of the vernacular terms *Inam, Zamindar, Zamindari* might well be made more illuminating.—[EDITOR.]

***

THE October-December (1918) Number of the **Bulletin of the Imperial Institute** (London : John Murray, 2*s*. 6*d*.) contains a comprehensive article on the Empire's trade in wool in its relation to the wool trade of the world. The total amount of wool produced is estimated at about 3,000 million pounds, of which almost two-fifths is contributed by British countries, Australia alone producing nearly one-fifth. Of the 460,000,000 lb. of imported wool used in the United Kingdom before the war, more than three-quarters came from British sources. Nevertheless, as is pointed out, Germany was actually using more Australian and South African wool than the United Kingdom. It is interesting to note also that the total consumption of wool in Germany was greater than in the United Kingdom, but it was chiefly of the inferior kinds. During the three years before the war the United Kingdom was exporting woollen manufactures of the average annual value of 27 million pounds sterling. Since then the growth of the industry has been remarkable. The average annual value of the exports of woollen manufactures has increased to over 36½ million pounds, and at present nearly twice as much wool is being used by the weaving industry as in pre-war times, and nearly the whole of it comes from within the Empire.

The article includes an account of the production of wool within the Empire and in foreign countries, and full particulars are given of the trade in woollen goods of the United Kingdom, the chief European countries, the United States and Japan.

The same number of the Bulletin contains an informative article on the manufacture and industrial utilization of paper yarns, which, during the war, were so largely used in Germany for fabrics of various kinds owing to the scarcity of jute and cotton. The manufacture of cordage and fabrics from paper yarn has been carried on in this country; but it appears unlikely that any extensive development of the industry will take place here so long as ample supplies of jute are obtainable at a reasonable price.

The section of the Bulletin devoted to an account of recent investigations conducted at the Imperial Institute includes a second report on samples of rubber prepared in Ceylon, in order to ascertain the best methods of preparing plantation rubber of the quality required by manufacturers; a report on the value of Indian tea seed as a source of oil; and a report on minerals from Rhodesia, including a general summary of the mineral resources of that country.

Correspondence.

A NEW USE FOR SUGAR IN THE CURING OF RUBBER.

To the Editor,

The Agricultural Journal of India.

Sir,

In the *Agricultural Journal of India*, Vol. XIII, Pt. IV, October, 1918, page 731, is a note headed " A new use for sugar in the curing of rubber," abstracted from the *Philippine Agricultural Review*, which attributes the discovery to Drs. Swart and Ultee of Java.

I should like to point out that this discovery was originally made by me in the laboratories of the Agricultural Department, F. M. S. (vide *Agricultural Bulletin*, Vol. IV, No. 2, November, 1915, page 26; and Vol. V, No. 2, November, 1916, page 48). Had reference been made to the original publication from Java by Drs. Gorter and Swart (*West Java Rubber Testing Station Bulletin* No. 6), the error in attributing the discovery to the above workers would not have arisen.

Drs. Gorter and Swart developed the investigation, which we were unable to continue at the time of our original discovery, and found that the sugar was converted chiefly to lactic acid.

The anærobic process for coagulation of *Hevea* latex, together with the necessary addition of sugars in many cases, was discovered and operated originally in the Federated Malay States.

I should be glad if you would insert this correction in your Journal.

Yours faithfully,

B. J. Eaton,

Agricultural Chemist,

Federated Malay States.

7th January, 1919.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

1. Everyman's Chemistry. The Chemist's Point of View and his Recent Work told for the Layman, by Ellwood Hendrick. Pp. x+319. (London: University of London Press, Ltd.) Price 8*s*. 6*d*. net.
2. Manual of Vegetable-garden Insects, by C. R. Crosby and M. D. Leonard. Pp. xv+391. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd.) Price 12*s*. 6*d*. net.
3. Botany: A Text-book for Senior Students, by D. Thoday. Second Edition. Pp. xix+524. (Cambridge: The University Press.) Price 7*s*. 6*d*. net.
4. A System of Physical Chemistry, by Prof. W. C. McC. Lewis. Second Edition. In three Volumes. Vol. III: Quantum Theory. With two appendices by James Rice. (Text-books of Physical Chemistry.) Pp. viii+209. (London: Longmans, Green and Co.) Price 7*s*. 6*d*. net.
5. A Handbook of Colloid Chemistry. The Recognition of Colloids, the Theory of Colloids, and their General Physico-Chemical Properties, by Dr. Wolfgang Ostwald. Second English Edition. Translated from the Third German Edition by Prof. Martin H. Fischer. With numerous notes added by Emil Hatschek. Pp. xvi+284. (London: J. and A. Churchill.) Price 15*s*. net.
6. Recent Advances in Organic Chemistry, by Dr. A. W. Stewart. With an Introduction by Prof. J. N. Collie. Third Edition. Pp. xx+350. (London: Longmans, Green and Co.) Price 14*s*. net.

7. The Science and Practice of Manuring for the Use of Amateur, Market, and Professional Growers, Orchardists, etc., by W. Dyke. With an Introduction by J. Wright. Revised and enlarged Edition. Pp. 157. (London : The Lockwood Press.) Price 2*s*. net.

8. Recent Advances in Physical and Inorganic Chemistry, by Dr. A. W. Stewart. With an Introduction by Sir William Ramsay. Third Edition. Pp. xv+284. (London : Longmans, Green and Co.) Price 12*s*. 6*d*. net.

9. Recent Discoveries in Inorganic Chemistry, by J. Hart Smith. Pp. x+91. (Cambridge : The University Press.) Price 4*s*. 6*d*. net.

10. Coniferous Trees for Profit and Ornament. Being a concise description of each species and variety with the most recently approved Nomenclature, List of Synonyms, and Best Methods of Cultivation, by A. D. Webster. Pp. xx+298. (London : Constable and Co.) Price 21*s*. net.

11. Agricultural Laboratory Exercises and Home Projects adapted to Secondary Schools, by Henry J. Waters and Prof. Joseph D. Elliff. Pp. vi+218. (Boston and London : Ginn and Co.) Price 4*s*. 6*d*. net.

12. Applied Analytical Chemistry, Methods and Standards for the Chemical Analysis of the Principal Industrial and Food Products, by Professor Vittorio Villavecchia. Translated by T. H. Pope, B.Sc., A.C.G.I., F.I.C., University of Birmingham. (London : J. and A. Churchill.) Vol. I, 21*s*.; Vol. II, 25*s*. net.

13. Mycology and Plant Pathology, by John W. Harshberger, Ph.D., Professor of Botany, University of Pennsylvania.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Special Indian Science Congress Number of the Agricultural Journal of India, 1919. Price, Rs. 2 or 3*s*.

Bulletin.

A New Nematode causing Parasitic Gastritis in Calves, by A. L. Sheather, B.Sc., M.R.C.V.S. (Bulletin No. 86.) Price, As. 4 or 5*d*.

Indigo Publication.

An Improved Method of preparing Indican from Indigo-yielding Plants, by Bhailal M. Amin, B.A. (Indigo Publication No. 5.) Price, As. 2 or 3*d*.

WITH the commencement of the New Year the Journal will issue bi-monthly, namely, in January, March, May, July, September, and November, while the Special Indian Science Congress Number will cease to appear as a separate issue, papers read at the Congress being published in the ordinary numbers of the Journal. A series of coloured plates illustrating some common Indian birds of interest to agriculturists will be a new feature of the Journal.

The rate of annual subscription will continue to be Rs. 6, while the price of single copies will be reduced from Rs. 2 to R. 1-8.

G. A. D. STUART,

Offg. Agricultural Adviser to the Government of India.

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Photo by George Craddock & Co.

COLONEL HENRY THOMAS PEASE, C.I.E., V.D., M.R.C.V.S.,
Principal of the Punjab Veterinary College, 1896-1907 and 1912-1919.

Original Articles

COLONEL H. T. PEASE, C.I.E., V.D.

COLONEL H. T. PEASE, C.I.E., V.D., Principal of the Punjab Veterinary College, retired on 20th July, 1919, after 34 years' service in India.

Henry Thomas Pease belongs to an old Yorkshire family, settled near Hull since the reign of Charles I. He is the son of F. R. Pease, Esqr., of Rusholme Hall, and was born in 1862. On leaving school, he took the diploma course at the Royal Veterinary College, London, and after some experience in a large practice in the north of England, he joined the Army and came to India in 1885.

In 1888 he was given an officiating staff appointment as Assistant Superintendent, Horse-breeding Department, and on the conclusion of that duty was posted as Veterinary Adviser to the Punjab Government and Professor in the Lahore Veterinary School. In 1891 he was specially selected as Superintendent of Bacteriological Survey, and posted to the Bacteriological Laboratory at Poona where he assisted Dr. Lingard in his researches into surra in horses. He soon realized that Poona was quite unsuitable for the requirements of a laboratory engaged in the study of contagious animal diseases. He was placed on special duty to select a more suitable site, and eventually chose Muktesar as possessing most of the necessary requirements. He received the thanks of the Government of India for work done in 1893, and was then appointed Assistant Inspector-General and placed in charge of the cattle and disease branch of the department, a post which enabled him to devote considerable time to the development of the laboratory and at the

same time to direct attention to cattle-breeding and the organization of the department for the treatment of disease in the districts. In the former direction he commenced to collect information regarding the good breeds of cattle, and prepared reports on the indigenous breeds in the Punjab, Mysore, Nellore, and Harriana, all of which were published in manual form. He also prepared a horse-breeding manual which was issued by authority, and for which he received the thanks of the Government of India. In regard to disease he endeavoured to stimulate research by the publication of up-to-date manuals on rinderpest, anthrax, hæmorrhagic septicæmia, black quarter, horse surra and ulcerative lymphangitis. He was also the compiler of the "Agricultural Ledger" on breeding, disease and cognate subjects.

In 1896 great difficulty was experienced in obtaining a Principal to succeed Col. Nunn at the Punjab Veterinary College and he volunteered to give up his appointment as Assistant Inspector-General to take up the work. But although Col. Pease left the Government of India, he remained their unofficial adviser in important matters connected with animal breeding and disease.

At the Punjab Veterinary College, he set himself to work to improve both teachers and students. He set about the preparation of text-books in Urdu himself and stimulated other teachers to do the same. He prepared books in Urdu on equine medicine, equine surgery, soundness and age, horse shoeing, handling of animals, veterinary jurisprudence and contagious diseases. In addition to this, he started and kept going for some years an Indian veterinary journal in Urdu. The present high reputation of the Punjab Veterinary College must be largely attributed to the excellent work of Colonel Pease. In 1905 he discovered the existence of a serious contagious disease among the horse-breeding stock, proved its contagious nature and demonstrated the cause. This was dourine, from which a great number of the stock were suffering, a disease which had doubtless for a considerable time made the results of the horse-breeding operations so bad. He also discovered the existence of hæmorrhagic septicæmia among cattle and buffaloes, and

was instrumental in bringing about the appointment of a Camel Specialist to deal with the diseases of that useful transport animal. In 1906, in collaboration with Baldrey and Montgomery, Colonel Pease started the "Journal of Tropical Veterinary Science," and from 1909, when the collaborators left India, carried on the work for four years practically single-handed. In 1906 he was awarded the title of C.I.E. for work done for the Government of India. In 1907 Colonel Pease was appointed to the post of Inspector-General of the Veterinary Department. He held the post until 1912, when the appointment was abolished, and then returned to the Punjab Veterinary College as Principal. On his return to Lahore the necessity for moving the college to another site had arisen, and he was called on to plan and equip the present new college, which he has made one of the best in the world.

The work which he has done is well known to scientists in all parts of the world and recognized by them. He was made a Foreign Correspondent of the Société de Médecine Vetérinaire in Paris and a Titulary Member of the Société des Sciences Vetérinaire. He is also a member of the Zoological Society of London. He was for many years a member of the Board of Scientific Advice.

In the midst of a busy life he has found time to devote to volunteering, and has for over 20 years been a member of the Punjab Light Horse, of which he was for years Adjutant and eventually Commanding Officer. The verdict of his comrades on his retirement was that his history was the history of the Corps. For his services in the Punjab Light Horse he was awarded the V. D. and appointed Honorary Aide-de-Camp to the Commander-in-Chief in India. For the services he rendered in connection with the Indian Defence Force in the war he was mentioned in despatches by His Excellency the Commander-in-Chief for valuable services rendered during the first three years of the war.

Colonel Pease is a distinguished Freemason at the head of the Craft, Chapter and Mark Degrees in the province.

The cheery humour and sound common sense displayed by Colonel Pease at successive meetings of the Board of Agriculture have endeared him to all officers of the present generation in the Veterinary and Agricultural Departments. The best wishes of all follow him into his well-earned retirement. [G. A. D. S.]

PLATE XXI.

Photo by Vernon & Co., Bombay.

The late ARTHUR WILFRED SHILSTON, M.R.C.V.S., Second Bacteriologist, Imperial Bacteriological Laboratory, Muktesar.

THE LATE ARTHUR WILFRED SHILSTON, M.R.C.V.S.

By the death of A. W. Shilston, from acute glanders, at the early age of 34, veterinary science in India has lost one of its most promising and valuable workers. In research and in routine work Shilston gave of his best. He had the true gift for research—foresight and rational imagination coupled with patience, perseverance and an infinite capacity for attention to detail. In routine he was prompt and resourceful. In both of these fields of work India is deeply indebted to him.

Shilston entered the Royal Veterinary College, London, in October 1904, and took his diploma in July 1908. His college career was brilliant and he was a marked man from the time he entered. Shortly after obtaining his diploma he was appointed to the Veterinary Research Laboratory at Pietermaritzburg, Natal, first as Assistant to Colonel Pitchford, and subsequently in charge. In March 1914, after a brief period of five weeks spent in England, he took up the appointment of Assistant Bacteriologist at the Muktesar Laboratories under Colonel Holmes. From February 1915 till October 1916, Shilston officiated as Imperial Bacteriologist, and afterwards held the appointment of Second Bacteriologist, up to his death.

In Africa Shilston did valuable work in connection with sheep scab, piroplasmosis, East Coast fever, and the production of anti-snake-venom serum. In India his energies were devoted to problems connected mainly with rinderpest, surra and dourine, and much valuable work in these subjects stands to his credit. Shilston first became ill on June 17th, and as he failed to make satisfactory progress he was sent on to Naini Tal on the 21st. The disease from which he was suffering steadily progressed and terminated fatally on July 6th. It can truly be said that his life was sacrificed to his work. [A. L. S.]

THE REPORT OF THE INDIAN COTTON COMMITTEE.

BY

FRANK NOYCE, I.C.S.,

Secretary to the Indian Cotton Committee.

THE issue of the Report of the Indian Cotton Committee is something of an event in the history of Indian agriculture. For the first time, the present position and future prospects of one of the great Indian staple crops has been exhaustively examined by a Committee of experts. An article on the Report in a Journal which is devoted to Indian agriculture is no more than its due, but the writer could wish that it had fallen to the lot of some one more competent than himself to contribute it. The Secretary of a Committee is, for obvious reasons, singularly ill-fitted to criticize its conclusions. All that can here be given is, therefore, some brief comments on the outstanding features of the Report so that any reader of this Journal who has not yet seen it may know what to expect.

The Report opens with an introductory chapter which gives an outline of the general position in regard to the world's supply of cotton which led to the appointment of the Committee. It also gives a brief description of the Committee's wanderings round India which extended from Lyallpur to Tuticorin and from Karachi to Calcutta. The Committee can claim that no important cotton tract was left out and that they visited many places in which no Imperial Committee had set foot before. In these pages, an expression of their grateful thanks for the hospitality which was showered on them everywhere, especially by officers of the

Agricultural Department, may perhaps be permitted. The Report proper is divided into two parts, the first of which deals with the agricultural and irrigational aspects of the problems which confronted the Committee and the second with their commercial aspect. The first part is again divided into chapters in which the cotton-growing provinces and Indian States are dealt with separately, and ends with some general recommendations regarding agricultural work on cotton. The second part contains four chapters only, a lengthy one on general commercial questions, more especially the question of preventing malpractices in ginning and pressing factories, one on cotton forecasts and statistics, one in which the establishment of an East Indian Cotton Association in Bombay, which will supersede the present Cotton Contracts Board, is recommended, and another in which the formation of a Central Cotton Committee to act as a link between the Agricultural Department and the trade is advocated.

The summary of the views and recommendations in the Report occupies fourteen pages of the octavo edition, sufficient evidence of the detail into which the Committee have entered. Whatever view may be taken of their proposals, there can be no question that the Report is a mine of information on all matters relating to Indian cotton.

The problem which the Committee set out to solve may be briefly described as being to secure an improvement in the quality and outturn of Indian cotton and at the same time to secure for the cultivator a better price for his improved product and increased outturn. The ways in which this problem can be solved as revealed in the Report are by more research work, especially on the botanical side, improvements in agricultural practice, the provision of irrigation facilities, better organization, the prevention of malpractices which lower the reputation and *ipso facto* the price of cotton, and last, but by no means least, closer co-operation between the Agricultural Department and the trade.

Of all the methods by which an improvement in the quality and an increase in the outturn of Indian cotton can be secured, the most important is botanical work, and the first point which strikes

the reader of the Report is the success of the efforts which the Agricultural Department has already made in this direction. In the Punjab, the United Provinces, the Central Provinces, Madras, and the Broach, Kumpta Dharwar and Khandesh tracts of Bombay, it has already evolved strains of cotton superior to the local varieties in staple, yield or ginning percentage (that is, percentage of lint to the total output of lint and seed) and, often, in all three. The Central Provinces with their 700,000 acres under *roseum* offer the best example of what such work has done to improve yield and ginning percentage, the Punjab with its 276,000 acres under Punjab-American and the Tinnevelly tract in Madras with its 220,000 acres under *karunganni*, the best examples of what it has done to improve staple as well. The staple of *karunganni* is at least an eighth of an inch longer than that of the mixture known as Tinnevellys and its ginning percentage is some 5 per cent. higher. The staple of Punjab-American is about $\frac{1}{4}$ to $\frac{3}{8}$ths inch above the average of the indigenous cotton of the Punjab and, though its ginning percentage is much the same, its yield is much heavier so that the outturn of lint is much greater. In the other tracts in which the Agricultural Department has evolved superior strains, they have been literally in the field too short a time to "catch on" in the way that *karunganni* and Punjab-American have done. In the Broach and Kumpta Dharwar tracts of Bombay, they have made but little headway. One difficulty has been the lack of a suitable organization to push them. The breakdown of the Surat buying Syndicate which was formed by some of the Bombay mill-owners proved very detrimental to cotton improvement work in Bombay. Another obstacle to rapid progress is the fact that Broach and Kumpta cottons are varieties of *herbaceum* which, as pointed out in the Report, is possessed of very stable characteristics. It is, therefore, difficult to secure anything in the nature of a recognizable improvement in it. This also applies to the Westerns cotton of Madras. In that tract and in the adjacent Northerns tract, the Agricultural Department has put out two improved strains, Hagari No. 1 and Sircar No. 2, but their superiority over the local cotton has not been sufficiently marked to justify perseverance with them and it is, therefore,

proposed to make a fresh start with two other selections, No. 25 in the case of Westerns and No. 14, an especially fine strain, in the case of Northerns. 4 F does not represent the last word in American cotton for the Punjab and the Committee recommend further experiments with 280 F and 285 F, strains which it may be of interest to mention have proved exceedingly successful in Captain Thomas' experiments in Mesopotamia. The Committee, again, are not satisfied that *roseum* in the Central Provinces and Khandesh and Aligarh white-flowered cotton in the United Provinces represent the *ultima thule* of the Agricultural Department, and are anxious to see further efforts made to evolve a superior variety of *neglectum* or *indicum* or a cross between them which can compete successfully with *roseum* or Aligarh white-flowered cotton in the matter of profit to the cultivator whose interests, it may here be stated, have been the predominating consideration with the Committee throughout. It will be seen that there still remains a vast field for botanical work in tracts in which superior strains have already been evolved. There are also large tracts in which no botanical work has yet been done at all. Hyderabad, which produces over one-seventh of the cotton grown in India, is the most important of these. Others are the Coconada tract in Madras and the Dholleras tract in Bombay. Very little work has been done on the indigenous cottons of the Punjab, and the Committee regard botanical work on Cambodia as the most urgent of the problems affecting cotton in the Madras Presidency. Burma is also practically untouched. The ten botanists the Committee recommend should be added to the Agricultural Department for work on cotton will thus find ample employment. This addition will enable more attention to be paid to crossing, the possibilities of which have been revealed by Mr. Leake's important work at Cawnpore.

Improvements in agricultural practice tend more to an increase in the outturn of cotton than to an improvement in its quality. It is too much to expect that the 85 pounds of cleaned cotton which is all that India produces to the acre will ever be increased to 200 pounds per acre as in the United States but much of the leeway can doubtless be made up, if the detailed recommendations made by the

Committee after careful examination of the conditions in each province, are carried out. The most important improvements advocated are the spread of the practice of sowing in lines and of inter-culture and the working out of suitable rotations which should include, wherever possible, heavy yielding leguminous fodder crops.

Extensions of irrigation are of special importance in the case of cotton for, in addition to the increase of acreage and outturn they secure, they also mean an improvement in quality. The increase in acreage is an obvious result, for such extensions permit cotton to be grown where it was not grown before. The increase in outturn per acre is equally obvious, for irrigated cotton yields more heavily than unirrigated. The improvement in quality is not so obvious but it is secured by the substitution of the better varieties of cotton which require a longer growing season for the shorter stapled ones. Broadly speaking, extension of irrigation means the cultivation of more American cotton for, in the Peninsula in which the longer stapled indigenous varieties are grown, cotton is not an irrigated crop except in the case of Cambodia under wells in Madras. Of the three great cotton-growing provinces of the north of India, Sind holds out the greatest possibilities and up till now has the poorest performance. Fifteen years or so ago, 200,000 acres of Egyptian cotton were expected in the course of a few years. In 1917, practically no American cotton was grown except on the Government farms. The Committee have no hesitation as to the cause to which this disastrous failure to realize expectations is to be ascribed and the whole of the chapter on Sind is a powerful plea for the immediate construction of the Sukkur Barrage across the Indus which would "transform some four and a half million acres of culturable land, at present sparsely populated and indifferently cultivated, into one of the richest and most productive tracts in India." It would incidentally result, according to the Committee's very moderate estimate, in an area of 660,000 acres under cotton, of which about two-thirds should be cotton of longer staple than any at present grown in India, not excepting the best Cambodia, and at least $1\frac{1}{4}$ inches in length. If the yield were no more than 160 pounds of lint per acre which the Report states is the outturn

of irrigated lands in the Punjab, this would mean an addition to India's supplies of long staple cotton of 160,000 bales. In the Punjab, the Committee anticipate a total of 465,000 acres under American cotton under existing canals in the course of two or three years against a total area of 276,000 acres in 1917, and a further addition of 200,000 acres if three big irrigation projects under contemplation are carried out. Outside Sind and the Punjab the prospects of long stapled cotton under irrigation are much more nebulous. The area under American cotton in the United Provinces *might* increase from the few thousand acres at present to 135,000 acres under the Ganges and Agra Canals, provided a sufficiently high premium for it could be assured. The addition of the proviso shows that the Committee were not very hopeful about American cotton in the United Provinces and that there is uphill work in front of the Agricultural Department in those provinces if it is to succeed. There are some small possibilities for Punjab-American in the North-West Frontier Province, for Cambodia on the lateritic soils in the east of the Central Provinces and for Cambodia or Upland Georgian on lands which formerly grew poppy in Central India. The cultivation of Cambodia under wells should spread in Madras but it is impossible to make any estimate of the prospects as no survey of suitable lands has been carried out. The only recommendation in the Report in regard to indigenous varieties under irrigation is that liberal *takavi* advances should be granted for the construction of wells in North Gujarat where greatly increased yields have been obtained in the Kaira District in such conditions.

The "better organization" which was mentioned at the outset includes the organization both of the Agricultural Department and the cotton trade. To the recommendations the Committee make in regard to the organization of the trade reference will be made later. As for the organization of the Agricultural Department, it will be obvious that if the cultivator is to grow better varieties of cotton and to obtain the proper price for them, he needs all the advice and assistance the Agricultural Department can give him. If "the selection and distribution of pure seed are to be controlled by the

Agricultural Department in the manner best suited to the local conditions of each tract," a large increase in the number of seed farms is necessary. If the Agricultural Department is to demonstrate on the requisite scale the usefulness of improved agricultural implements and to convince the cultivator of the advantages resulting from the use of manures and from good cultivation, a large increase in staff is necessary. Such an increase is, above all, necessary, if the Department is to be in the best possible position to assist the cultivator in getting a better price for a superior product. The various ways in which this end can be secured are discussed in the Report. Warned by the fate of the Surat and Sind buying Syndicates, the Committee decide against buying agencies. The prospects of co-operative sale are hopeful but this is an agency the growth of which cannot be forced and something else is required. The Committee, therefore, advocate an extension of the system of auction sales of unginned cotton which has proved so successful in the Punjab, but consider that the Agricultural Department should not in any one case attempt to deal with more than 60,000 maunds of cotton which would give it control over 40,000 maunds of seed. After that, the sales should be handed over to other agencies, but the Department would still be called upon for advice and assistance in regard to such matters as grading, classification and the settlement of disputes. All this means a considerable expansion of what it is now the fashion to call "organization" and the additions to the staff of the Agricultural Department recommended by the Committee, apart from the ten Botanists mentioned above, an Entomologist for the United Provinces and an Imperial Mycologist, are one Director of Agriculture for Sind, thirteen Deputy and Assistant Directors of Agriculture belonging to the Indian Agricultural Service and three Assistant Directors belonging to the Provincial Service. For Indian States, the immediate additions proposed are two Directors of Agriculture and two Deputy Directors. The subordinate staff must, of course, be increased proportionately. The total annual cost of these proposals is estimated at Rs. 14 lakhs, which cannot be considered excessive in view of the importance of the cotton crop to India.

It is of little use for the Agricultural Department to spend its energies in inducing the cultivator to grow pure or superior varieties of cotton and to pick them clean, if he is prevented from securing the proper price for them by malpractices which he is powerless to check. The Committee give the cultivator a good character in this respect and state that the malpractices for which he and the village *bania* are responsible are of minor importance compared with those which are carried on in ginning and pressing factories. The recommendations in the longest and most important single chapter of the Report are directed to securing an improvement in the conditions which have made Indian cotton "a byword in certain markets almost throughout the history of the British connexion with India." The opening of central markets on the Berar system which enables the purchaser of cotton to see what he is buying and to pay for it accordingly, the publication of cotton prices in up-country markets in a way which will enable the cultivator to understand their true significance, and the standardization of weights on the basis of a cotton maund of 28 pounds, which will prevent his being cheated by the middleman, are all measures calculated to bring about the desired effect, but far more important than any of them is the system of licensing ginning and pressing factories which is recommended by the Committee. For the details of this scheme, the reader must be referred to the Report itself. Suffice it to say that, in future, the way of the offender will be very much harder than it has been in the past and that it should no longer be possible to fob off the man who produces a superior variety of cotton with the price of the inferior stuff with which it has hitherto been far too often the practice to mix it. Warned by the history of the Bombay Cotton Frauds Act, the Committee have worked out a scheme which involves the minimum of interference with honest factories. There will be no inquisitorial inspections by poorly paid subordinate officials which was the great grievance against the Bombay legislation. Complaints will be made by the sufferers and will be investigated by Committees on which the trade will probably have a preponderance of representation. If the trade is satisfied with bad cotton and prefers to pay for rubbish, there will, of course, be no

complaints and things will remain much as they are, but it is inconceivable that this should be so. Even if it is, one fruitful source of mischief will be removed for, under the Committee's proposals, the transport of cotton waste or of short staple cotton from one tract to another for the purpose of mixing with better varieties will be prohibited.

The chapter on cotton forecasts and statistics generally is worth study for many of the recommendations in it are applicable to other crops than cotton. Considerations of space prevent more than this brief reference to it.

We mentioned above that the Committee have suggested not only better organization of the Agricultural Department but also of the cotton trade. The way in which they propose that this should be brought about is by the establishment of a Central Cotton Trade Association in Bombay which, as far as control of the cotton trade is concerned, will take the place of the seven distinct bodies representing different branches of the cotton trade which existed at the time the Report was written and still exist, though the functions of two of the most important of them, the Bombay Cotton Trade Association and the Bombay Cotton Exchange, are at present exercised by the Cotton Contracts Board. The "East India Cotton Association" will be the permanent successor of the latter and there can be no doubt that its establishment will have a far-reaching effect in stabilising the price of cotton to the ultimate benefit of the cultivator.

In their last chapter, the Committee make provision for the much needed link between the Agricultural Department and the cotton trade. There can be no question that, valuable as the work which has already been accomplished by the Agricultural Department in improving Indian cotton, it would have been much more fruitful in results had there been closer co-operation between it and the cotton trade. Up till now, each of them has been amazingly ignorant of what the other has been doing. It would be an unprofitable task to apportion the blame for this. As the Irishman said when asked why an unpopular landlord had not been shot, what is everybody's business is nobody's business. There will, in

future, be no excuse for ignorance, for all interested in cotton, whether agriculturally or commercially, will be able to turn to the Central Cotton Committee for advice and assistance. It is proposed that this Committee should consist of about twenty members of whom nine will be officials. These will be the Agricultural Adviser to the Government of India who will be President, six agricultural experts working on cotton in the six great cotton-growing provinces, the Director General of Commercial Intelligence and the Director of Statistics. The remaining members, with the exception of a representative of the Co-operative Department who may be either an official or a non-official, will be representatives of Chambers of Commerce and similar bodies and will include a representative of Lancashire interests. Though the functions of the Committee are to be almost entirely advisory, its advice will be the best expert advice obtainable and will be of special importance in regard to the working of the system of licensing of gins and presses, as the penalty of withdrawal of the license of an offending factory will be inflicted on its recommendation. The Agricultural Department will no longer be in the dark as to what the trade really wants nor, as has been the case very frequently in the past, will it be confronted with conflicting reports as to the value of its improved strains. The services of the Technologist whom it is proposed to add to the staff of the Committee will be very valuable to it in the latter connexion. It should be mentioned that the Central Cotton Committee will work to a large extent through provincial and local sub-committees. If it becomes an accomplished fact, it should lead to an immense development of one of the most important raw materials which India produces.

MOTOR TRACTOR TRIALS AT PUSA.

BY

WYNNE SAYER, B.A.,

Offg. Imperial Agriculturist.

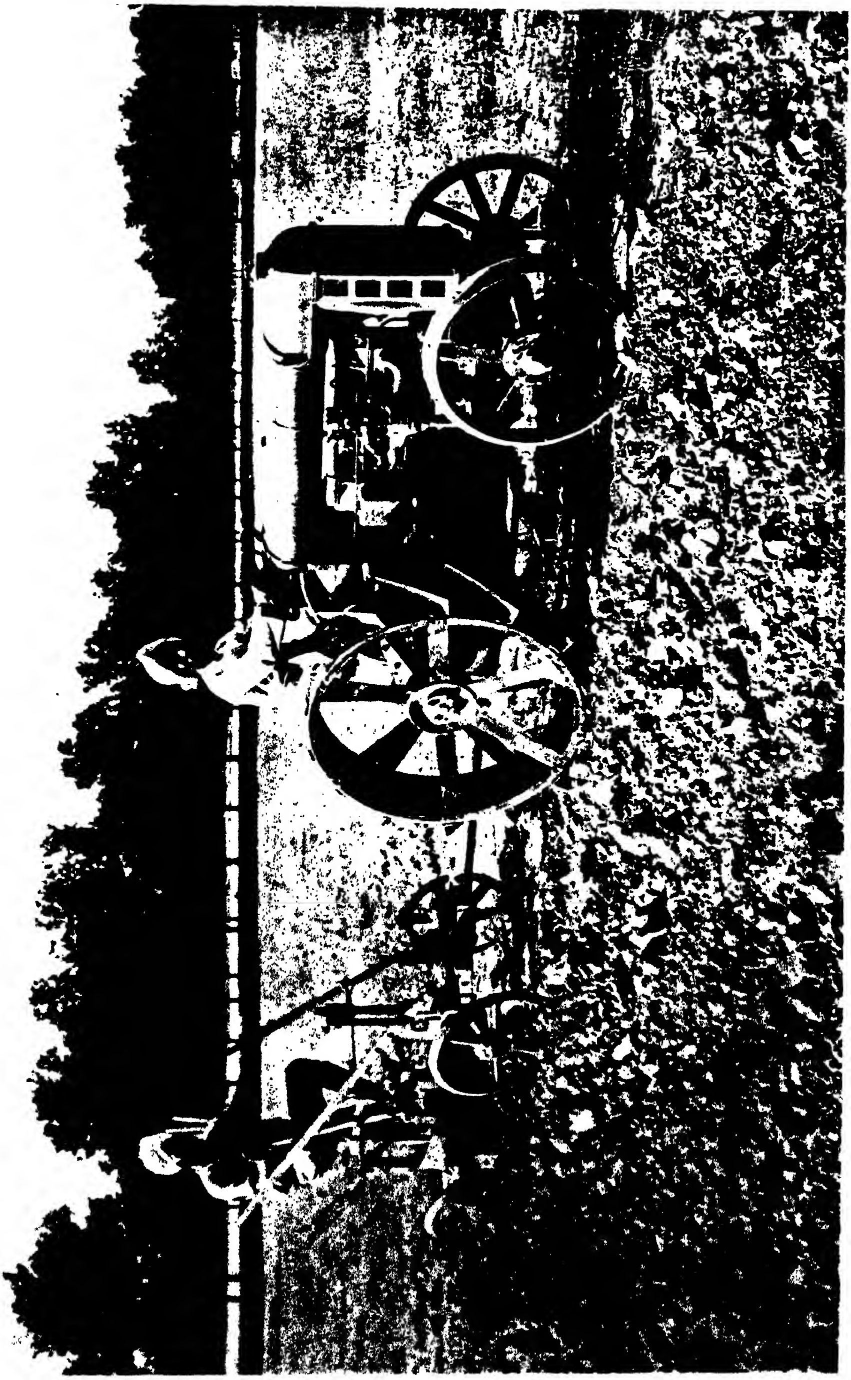
It being clearly evident from reports received from home that a type of motor tractor for agricultural work had been evolved which was capable of doing excellent work under ordinary farm conditions, arrangements were made to secure the first tractor imported into India of the type most likely to suit Bihar conditions in order that a trial might be undertaken on the farm at Pusa in the benefit of the agricultural public. The Fordson was chosen for four very obvious reasons :—

1. It was light and handy.
2. It was fully supplied with spares.
3. It was likely to be available very shortly, it was cheap, and if the demonstration was successful no difficulty would be experienced in procuring others.
4. It had done excellent work in all hands and under all conditions in England and was obviously a type of tractor which had been thoroughly tested.

It will perhaps be best to give a description of the Fordson here which, coupled with the photographs (Plates XXII–XXV), should make its details fairly clear to all.

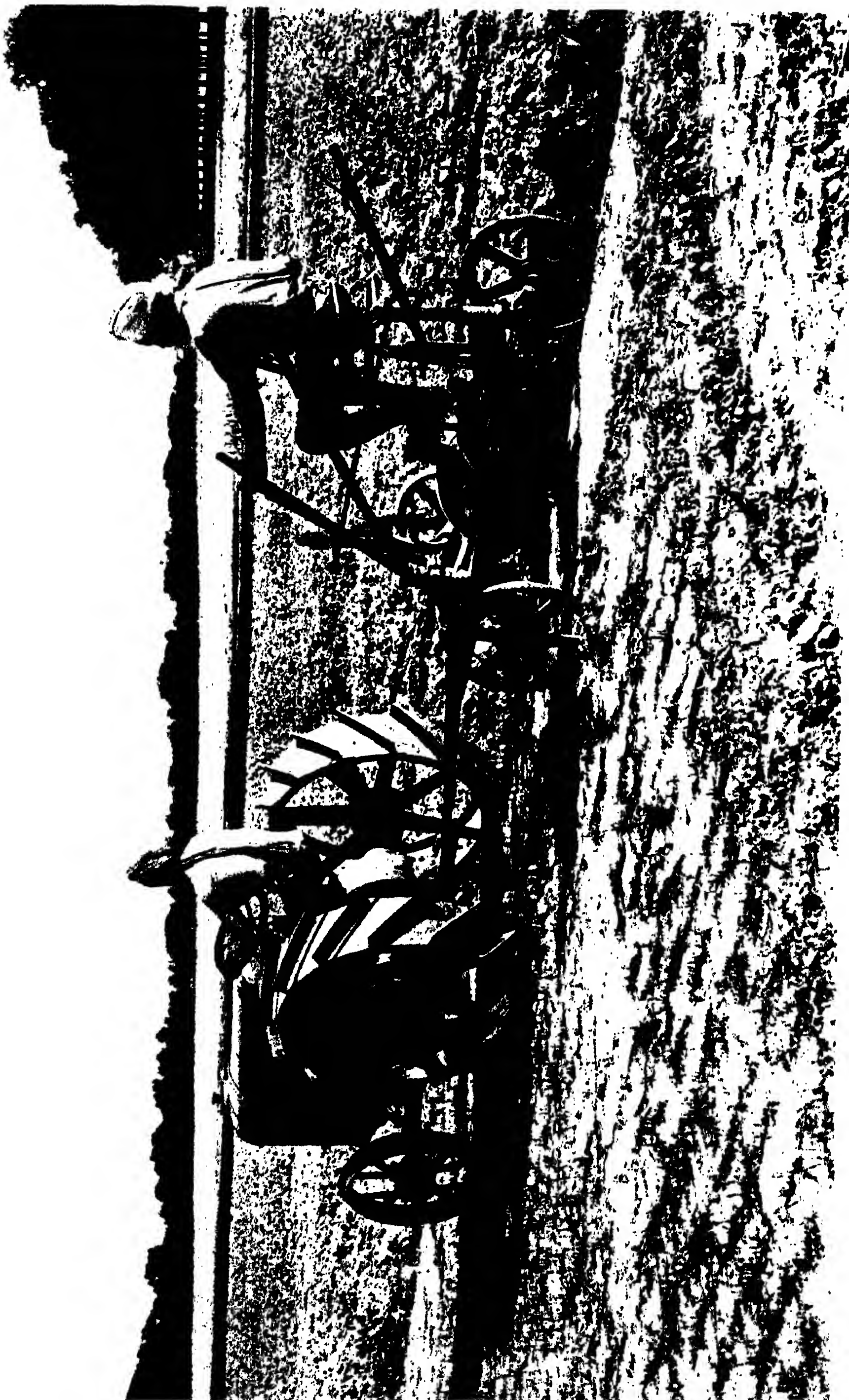
The Fordson motor tractor is so constructed that the engine and all the working parts form the frame of the machine. A unit " Power Plant " is bolted to and forms a unit with the rear axle in the shape of a big T. In this T are stowed all the working parts.

PLATE XXII.



Fordson Motor Tractor: view of engine from intake side.

PLATE XXIII.



Motor tractor working with double disc plough.

The T is mounted on four solid wheels. The wheel base is 63 inches and the tread is 38 inches. The tractor will turn in a 21-foot circle. The rear wheels are 42 inches in diameter with 12-inch rims. Overall length is 102 inches, height 55 inches and width 62 inches. The total weight of tractor is 2,700 lb. with water and fuel tanks filled, which hold 11 gallons and 21 gallons respectively.

The tractor can be used for a double purpose—both for hauling and ploughing. Its capacity as regards the latter is two 14-inch ploughs which are hauled at $2\frac{3}{4}$ miles per hour with the engine running at its normal speed of 1,000 r.p.m. The drawbar pull at ploughing speed is 1,800 pounds, which is increased to 2,500 pounds at low speed of $1\frac{1}{2}$ miles per hour. For road work and running light from place to place, there is a speed of $6\frac{3}{4}$ miles. The reverse is $2\frac{1}{2}$ miles an hour. For stationary work, a pulley is fitted on the side of the tractor and operated from the engine clutch. Twenty-two horse power is available at the pulley which runs at 1,000 r.p.m. The pulley is 9 inches in diameter and uses a six-inch belt.

The engine has four cylinders, each 4×5 inches. Petrol is used for starting, and when the vaporiser is sufficiently heated, kerosene can be substituted. The consumption of fuel varies naturally with the conditions, but is said to be not likely to exceed $2\frac{1}{2}$ gallons of kerosene per hour on the average. When the engine is at stationary work and running on full power, the consumption amounts to two and three-quarter gallons per hour.

The cost of the Fordson tractor is Rs. 4,250 f. o. r. Calcutta, and the Russa Engineering Works, Ltd., Calcutta, are the agents in India.

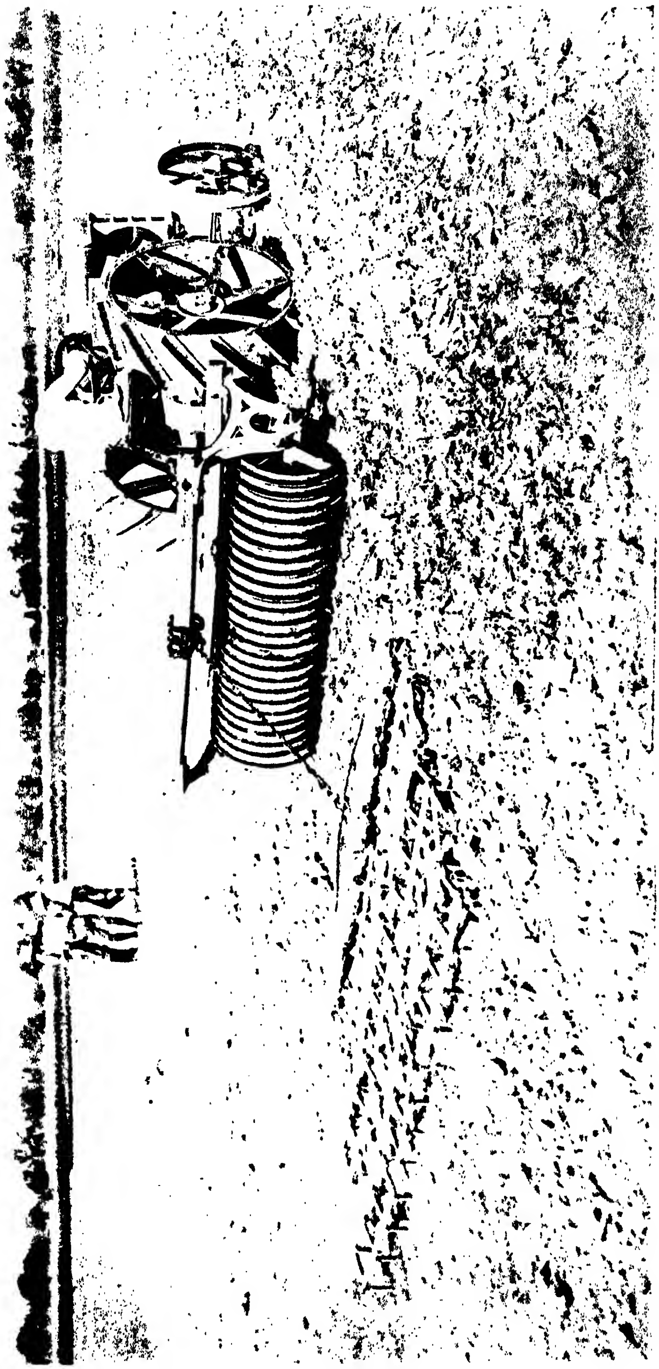
The tractor unfortunately arrived in India without any of the implements with which it was meant to be worked, but as it was all important to get some idea of its powers under Indian conditions (the quality of the work done being purely a question of the implements used), it was decided to use it with the implements available on the farm which, not having been designed for tractor haulage, made the test extra severe.

The tractor was worked on the farm for some days previous to the trial in order to familiarise the farm staff with it.

It was a welcome surprise to find from the start that at last an agricultural motor had been evolved which was obviously designed by some one who did really understand what was essential in dealing with agricultural conditions. Previous experiences in this line had shown us that whatever might be said in pamphlets, up to the introduction of the Fordson, no motor had been tried in India which would work under ordinary agricultural conditions; but here there was a total absence of the wild ideas about Indian conditions usually incorporated in agricultural machinery imported into India. The tractor proved easy to handle. The engine was exceptionally accessible in all parts (what this means, only people who have had to do running repairs to an American engine can tell). It was undoubtedly powerful, exceptionally handy and easy to drive; and as soon as the method of starting on petrol and the switching over on to kerosene had been explained, there was nothing else that the average *mistri* with a small knowledge of motor cars could not easily grasp; and once all those who drive a Fordson have found out by personal observation that if you let your clutch in too quick when in a bad place, the tractor rears up, you do not need to repeat the warning. This is the only risk other than those inseparable for the average moving vehicle and must be carefully guarded against and I would take this opportunity of warning all users of Fordsons in India about it. Some means of switching off the engine directly the tractor starts to come up, will have to be found, as a machine of this lightness and power will always wind itself up on its back axle under such circumstances. There is also a chance of burning out the vaporising tube if you allow the engine to run too long on petrol before switching over, and some means should be invented of cutting off the supply of petrol before this can happen in cases where, either from ignorance or accident, the engine is left running on petrol too long. A spare vaporiser tube should also be kept handy, and with the usual couple of spare plugs in reserve, no trouble should be experienced in running, provided the usual care is taken with oil and water supplies.

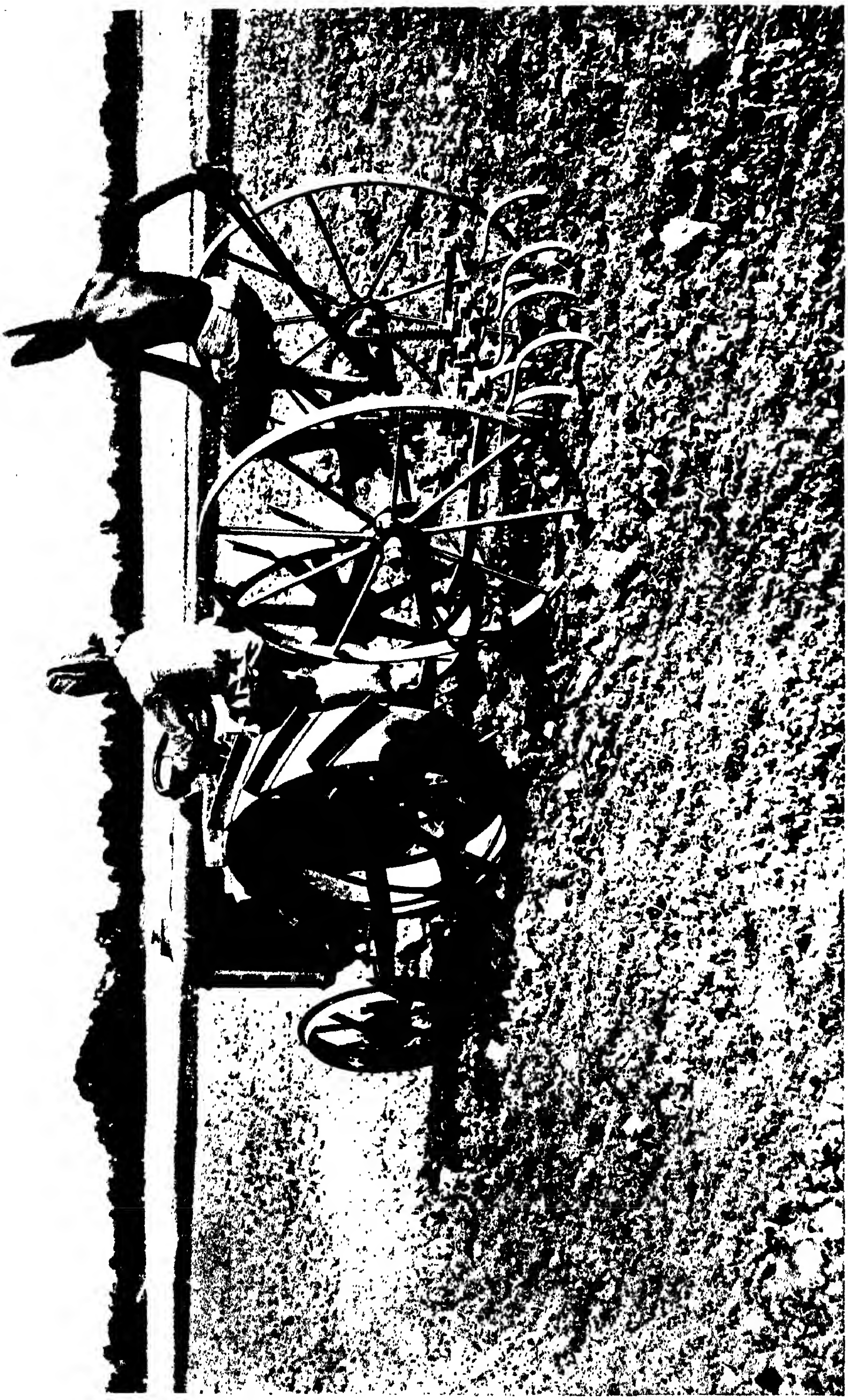
The land chosen for the trial was a piece of typical oat stubble which, owing to the continuous dry weather, had worked down pretty

PLATE XXIV.



Motor tractor working Cambridge roll and rake of spring tooth harrows.

PLATE XXV.



'or trac wo ng Ransome's 8 ne cultivator.

hard. A piece of land, 400 yards × 20 yards, was marked out for the ploughing and another similar strip for the cultivator.

The tractor was first hitched to a double-furrow Ransome's disc plough which is pulled as a rule by three pairs of big bullocks. It worked this easily, the engine running with a good reserve on second speed and the way in which tractor and plough turned on the small head land was remarked by every one. Judging from the pace at which the work was done and the reserve which the tractor had in hand, it seems that it will be possible to do the class of ploughing required on such lands with a three, instead of a double, furrow plough.

A Ransome's 8-spring tined cultivator was then attached and another strip was grubbed at a depth of 5 inches. The way in which this work was done was especially notable for the ease with which the cultivator worked the land and the rate the tractor travelled at, and many present thought this method of dealing with stubble to be preferable under Bihar conditions to ploughing. The work done by such an implement, working 3 feet wide with 8 tines, approximates to that of the average iron plough used which while loosening does not invert the soil, while the breadth covered by the cultivator at each run is equal to 5 ploughs.

A rake of 3-spring toothed harrows was then run over the ploughed portion and much interest was displayed at the way the tractor travelled over a loose surface, showing no sign of poaching or failure to grip the soil.

A Cambridge roll was then worked over the ploughed land and the remarkable efficiency coupled with the extreme lightness and handiness of the tractor, became evident. She travelled over the ploughed land easily and quickly, doing the work perfectly efficiently and finding no trouble from the depth and looseness of the soil, and the driving wheels, while breaking up the clods, did not pack the land at all. The tractor was very carefully watched with regard to this as it has been the chief thing to be feared with a mechanical prime mover working over the land.

The tractor was then run off the land and driven on top speed up to the farm buildings where the driving pulley was fitted and the

Climax silage cutter worked for half an hour. The engine took the load easily and ran regularly and steadily. Despite the extreme heat of the day, at no time did the water in the radiator approach boiling point, and the method by which the air taken into the carburetter is filtered through water, enabled the tractor to work in the heaviest dust without any choking. In short, the demonstration and trial, as far as proving the capabilities of the tractor went, were perfectly satisfactory. It now remains to test the tractor for fuel consumption, etc., and to watch its behaviour and work over a period in the hands of the average *mistri.* Tests to this end together with trials of the most suitable implements, especially for Bihar conditions, will be conducted, and I would take the opportunity of replying to all—and their number is legion—of the people who have spoken and written to me about this tractor as follows :—The tractor is under trial and **I can express no opinion and give no figures yet** but a report will issue in due course. A set of photographs taken by the cinematograph (Plate XXVI) illustrate this article showing the machine at work, and I shall be only too glad to show any one the machine working any day if they will write to me and fix a date.

I hope in the near future to have an engineer working in collaboration, as these experiments will require combination of engineering and agricultural knowledge to enable them to be thoroughly and satisfactorily carried out.

PLATE XXVI.

Motor tractor trial views from cinematograph film.

VEGETABLES DURING THE MESOPOTAMIAN CAMPAIGN.

BY

CAPTAIN G. C. SHERRARD,

Deputy Controller (Agricultural Requirements, Mesopotamia), Indian Munitions Board.

U is the lake known as Um-el-Brahm
Which guards our left flank from all possible harm
And waters old Gomigee's barley farm
In the middle of Mesopotamia.

Mesopotamian Alphabet.

I BEGIN with the above quotation from that delightful doggerel the Mesopotamian Alphabet, because it is the first popular reference to agriculture made by the army in Mesopotamia. Unfortunately I can find no one who can tell me who Gomigee was, or where his farm.

I should like to talk about the Mesopotamian Alphabet, because I believe it contains, if read with sympathy, a real guide to the spirit of the old army, the army that fought its way under great difficulties to Ctesiphon, and nearly to Baghdad. The men who knew that things were going wrong, but, because soldiering was their "job," did not rave, or stop,—they joked. In the Alphabet the laugh at the ruling powers has something of an edge, but that at individual services is good-natured chaff, without a sting. The army that produced the Alphabet knew that the medical service was ill-equipped, that the transport was breaking down; but it also knew that the individual doctor was working night and day, that single transport officers were trying to do alone work that was later given to four or more, paying in mind and body for the strain. All this was changed. When I arrived the change had well begun; but I heard and saw enough to make me realize what went before.

Later, a new generation arrived, while conditions altered greatly ; so the Mesopotamian Alphabet was very near forgot.

This, however, is not a paper on Mesopotamia, or the army, old or new, but only an account of the work of a branch of the Indian agricultural department, planted out behind that army in the field. It is unfortunate that the account contains so much of the letter I, but, as I have been asked to write a description of my work, and have not the necessary literary skill, I have had to do it the easiest way—and I ask for your indulgence.

I believe that Mr. Maxwell-Lefroy first suggested that a member of our department should go to Mesopotamia to grow vegetables and help to fight scurvy, when he returned from a tour in that country undertaken to advise on the destruction of flies. The proposal was seconded by Mr. Mackenna, and, I am glad to say, I was chosen for the work.

On August 13th 1916 I received a copy of a letter from the Government of India, which said, " it is proposed, with a view to obtaining supplies of fresh vegetables for the troops in Mesopotamia, that the Agricultural Department in India should assist in the introduction into that country of vegetable cultivation by lending to the Army Department the services of a Deputy Director of Agriculture with a staff of *malis*, and that Mr. Sherrard * * has been suggested as the most suitable * * if * * (he) is willing to undertake the duty * * (he) should be instructed to engage twelve *malis*." This raised many questions ; but chiefly, two. What, exactly, was expected ; and, why twelve *malis* ? A visit to Simla did not elucidate matters to any great extent. There was an unformed idea that a vegetable farm should be started, but no explanation as to the reason for the precise number of twelve *malis*. The most definite statement was that of General Bingley, who said, " There are 175,000 men in Mesopotamia, and hardly any vegetables." Perhaps no one else put the facts so plainly for fear of scaring me out of my wits, even as it was I had a strong impulse to fly, and bury myself in the uttermost wilds of Bihar.

The next step was to collect the twelve *malis*. In those excellent market gardeners, the *koiris* round Bankipore, I thought I had

exactly the right material to my hand. But the *koiri* is timid, painstaking, and averse to leaving his native home (for which reason he is much sought after by landlords), and, though I had no difficulty in finding twelve good men, nothing would induce them to go to Mesopotamia, and they invariably bolted the day before they were to be entrained. It was very much like taking a sieve of oats to catch twelve shy colts loose in a large field. Obviously it was more important to find out what was happening to the 175,000 men with no vegetables, than to waste time endeavouring to overcome the coy reluctance of the *koiris* of Bihar. So I proceeded to Bombay.

There, and at Poona, through the good offices of the Director of Agriculture and the Economic Botanist, I was able to collect seven out of the twelve *malis*, and to make arrangements for vegetable seeds to be sent out to me from India as required. I then left for Basrah, where I arrived on September 16th 1916 and reported to Brigadier-General P. C. Scott, C.B., Director of Supplies and Transport, Mesopotamian Expeditionary Force. After some consultation, it was arranged that work in connection with the production of vegetables should become part of the S. & T. organization, and I was put under the orders of the D. S. & T.

It was now that I fully understood what was expected of the agricultural expert. Scurvy cases were being admitted to the hospitals at the rate of 3,000 a month, and evacuations and deaths were very numerous. There was a definite hope, therefore, that sufficient vegetables would be produced, to provide everyone with the regulation daily ration of 12 oz. of fresh vegetables for British and 6 oz. for Indian troops, and to stamp out the disease. However, though this was the object to aim at, the authorities were quite willing to admit that it was difficult to obtain, and that the full ration could only be raised with time, if at all. Their attitude, and particularly that of General Scott (with whom I dealt direct), was extremely helpful, and created a pleasant atmosphere to work in. It was as if they said : " You understand that the position is serious. As an agriculturist you will know best how to produce the vegetables. We will not interfere, or hamper you, and will give you what you

ask for (as far as this is possible among the conflicting demands of many important works); and then we hope for results." This is the army way, and it is a pity that it is not more common in civil life.

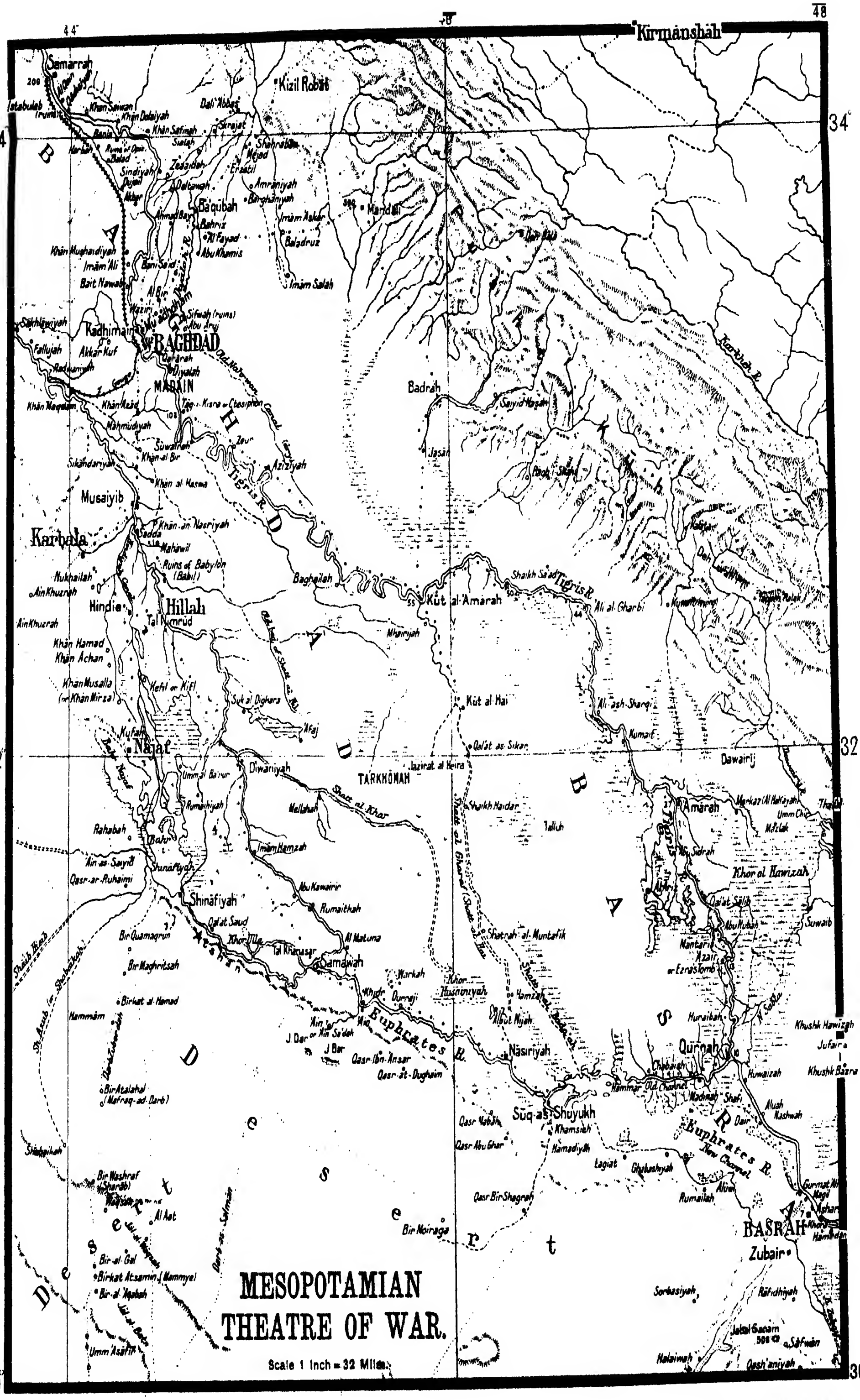
Later on arose the question of my official title. "What shall we call you?" "Anything that you think will do." "What were you called before, in your own service?" "A deputy-director of agriculture." "Well, that is quite a good name, go on calling yourself that, unless someone objects in the future." And so it became, temporarily, an official title in the S. & T. Corps. It was interesting—and, perhaps, amusing—to be the first deputy-director of agriculture ever attached to a British force in the field. The following pages attempt to show the doings of this small agricultural department up to the end of 1917, when it passed over to civil administration, and its story more properly belongs to the early history of the Mesopotamian agricultural department.

I. Before the advance.

You all know the position in Mesopotamia in September 1916, and here (as elsewhere in this report) it is only recalled sufficiently to explain what follows.

The army was holding the lines at Sannayat and Sinn, on both banks of the Tigris, and its supplies were sent up the river 243½ miles, by steamer and barge, from Basrah to the advanced base at Shaikh Saad. From there they went, either by a light railway up the right bank, or by smaller boats to Arab Village, 22 miles further up the river.

The facilities for unloading the steamers and loading the river barges at Basrah were improving with almost marvellous rapidity, and continued to improve. But the railway from Qurnah to Amarah had not yet been built, and the whole line depended upon the river craft, a miscellaneous collection of paddle-boats and tugs, that had been recruited from all corners of the Empire. East Indian Railway boats, that had ferried the ryot across the Ganges; stern-wheelers, that had taken the tourist up the Nile; London County Council boats, that had carried the cockney on the Thames; Irrawady boats



MESOPOTAMIAN THEATRE OF WAR.

Scale 1 Inch = 32 Miles.

from Burma; harbour tugs from Rangoon ; all now painted the same light grey, each with a couple of barges, toiling up and down. Their numbers were constantly being increased, but none of those specially built in England for the work had yet arrived, and the cry was always for more.

The advanced base at Shaikh Saad was a large, long camp on the right bank, with a tiny uninhabited Arab village tucked away in one corner of it,—aerodrome, hospitals, rest camp, troops, ordnance, supply depôt (largely supply depôt), a bridge of boats, and a bridge-head on the other bank ; the whole protected on the landward side with defence posts and continuous barbed wire. To a new arrival the general impression of the place—besides dust—was of innumerable gangs of khaki-clad men slowly carrying boxes and bales from barges and dumping them on the foreshore. Sometimes they were fatigue parties, but usually they were coolies—men of the porter corps. No Arab was allowed within rifle shot of the place (though he often crept in, uninvited, at night, to steal—and occasionally to stab), and all the work was done by the force. Though the labour and porter corps were steadily increasing, there was not then, nor for a long time, enough labour to supply the various demands ; every cooly might almost be said to be fought for among the many departments demanding his time. But all this was on paper, the actual individual went on quietly carrying his box of biscuits to the shore, or his basket of earth to the bund, without showing any particular concern.

Having completed the journey to Shaikh Saad, a report was made on the possibility of importing potatoes and onions from India. Various attempts to do this had been made in the past but without success ; nor was this to be wondered at, judging by the stories of the men on the ocean-going steamers and the river craft. The potatoes had been packed in sacks, treated as ordinary cargo, and placed in the hold, sometimes with other goods on top of them. They then had to be transhipped at Basrah, first to the shore and then to the barges, where they were again heaped up. I was assured that in some cases they were half rotten before they left India, they were certainly often bad before they reached Basrah. It was,

therefore, suggested that potatoes should be carefully selected and picked over in India, packed in crates, kept ventilated and unbruised, treated as perishable goods, and sent up the line with despatch, when it should be possible to supply the force, without a prohibitive loss, for the greater part of the year. One or two other letters and suggestions were submitted on the subject, and the authorities in India took the matter up. The result was a very great improvement, so that even in the heat of June 1917, potatoes were arriving as far up the line as Samarrah, 70 miles above Baghdad, with a loss of less than 50 per cent. in transit ; a journey which, measured in time, is probably the longest that potatoes have ever been sent in large quantities. A loss of 50 per cent., however, was too large to make it worth while importing potatoes during the hot weather, and the export from India was stopped during May ; it being arranged that in future potatoes should not be shipped between the end of April and the middle of September. Onions were received throughout the year but, as the local supply of fresh vegetables increased, the quantities were gradually reduced, and the importation ceased at the end of 1917. Though there was a very rapid improvement in this supply, there were, of course, mistakes at first (for example, furious wires were flashing about, in December because numbers of potatoes were still arriving crushed in sacks, in January because some harassed officer had sent them up the line in country boats, which took ten days to reach Amarah alone, where the potatoes arrived bad), but these were gradually almost entirely eliminated, and were due, as were similar incidents in other branches of the work, not to any difficulty in convincing those in authority of what was required, but to the impossibility of educating a large number of hard-worked and constantly changing juniors in the correct way of treating a travelling vegetable.

The advantage of a vegetable garden at Shaikh Saad had been realized for some time, and four and a half acres had been set aside latterly for the purpose, while two *noiria* pumps had been ordered. Four and a half acres, however, would not go very far, so fifty acres were selected, with some difficulty, for a farm. It was found impossible to obtain more than this, as the area had to be inside the

defences, and was further circumscribed by the camps and roads, and the salt patches so common along the lower Tigris. An oil-engine and pump, together with various implements, were ordered, and plans drawn up for irrigating and laying out the farm. I then proceeded down-stream to Amarah.

Amarah, actually a small place, is the most important town between Basrah and Baghdad. It is situated 112 miles by river below Shaikh Saad, at the junction of the Tigris and the Chahala canal. As at Shaikh Saad, the whole place was surrounded by block houses and barbed wire, but the local Arab was much more encouraged, as he was less obstreperous. True, he was instantly fired at if seen by the sentries outside the perimeter at night, while if he lived in the town he was encouraged to go to bed at an early hour, but during the day he was allowed to wander about almost at will, to attend to his own affairs, to occupy himself with his cultivation or to work for us in the depôt or on the roads.

A second canal, the Mashera, takes off from the Chahala just after the latter leaves the river. There are thus three streams (the Tigris, the Chahala and the Mashera) from which water may be raised to cultivate the land, irrigation from all three being by lift and not by flow, except when the river is in full flood. Several forms of water-lifts and pumps were in use : *noiria* pumps, a wheel with an endless chain of small buckets, worked by a blindfolded pony and a primitive wooden gear ; *chereds* (the *mhote* of India), large leathern bags with a trunk at the end, self-discharging, and attached to a diminutive pony or cow that raises the bag by going headlong down an extraordinarily steep incline ; even several oil engines and centrifugal pumps. The cultivation is a narrow strip on each side of the three waterways. Near the town a number of date groves, among these and on fields further out the land is put down under barley or wheat ; and in and out among the date palms were small patches of vegetables.

On October 13th 1916 a report was submitted giving proposals for carrying out the work which were much the same as those on which it ultimately developed. The area necessary to provide the vegetable ration for the force was very much larger than was

generally supposed, and all ideas that a few acres here or there would suffice must be abandoned. The fifty-acre farm at Shaikh Saad would be put under cultivation as soon as pumps, implements and men were forthcoming, but the main supply must come from elsewhere. If this was grown by military labour, it would require a large number of men, who at present were not available, besides pumps and implements. It was more advisable, therefore, to utilize Arab labour, and to extend the present vegetable cultivation in such places as Amarah and Ali-al-Gharbi, where irrigation facilities already existed, or could be increased on existing lines. To get the best results, however, besides the agricultural side, comprising the general supervision of the crops sown, it was essential that there should be prompt payment in cash for the produce when harvested. Again, as work with the aid of local cultivators, under existing conditions, would have to be undertaken some way behind the lines, it was of the utmost importance that the vegetables so obtained should be collected in one place as soon as possible after harvest, carefully packed, and immediately shipped to the front. The work itself is described below under the three heads, growing, collecting and transporting.

GROWING.

There was a general idea that no vegetables were grown in Lower Mesopotamia before the war, and that, therefore, the Arab knew nothing of their cultivation. This was not the case. That there were few vegetables is true, for the marsh Arabs, and those in the smaller villages, contented themselves with a kind of mallow and other plants that grew wild ; and this applies to the poorer classes in the towns. But in Basrah, Amarah and Nasiriyah, fair quantities of vegetables were consumed by the inhabitants, though the number of men with experience in their cultivation was limited. In order to increase the production several difficulties had to be overcome. First, and most important, it was necessary to convince the landholders that vegetable-growing would pay, and that it was to their advantage to put their energies into this as much as into their date gardens. Secondly, labour was scarce ;

Amarah was not a large place, and the roads, railway, and other works, created a ready market at higher rates than the landholders could afford. Thirdly, heavy irrigation was necessary, and water-lifts or pumps had to be provided in addition to those already in use. Fourthly, seed was required. Lastly, the time for sowing the cold weather crops was rapidly passing.

A meeting was immediately called of all the men having land in the neighbourhood, and they were told that a very large increase in the area under vegetables was required, and were assured that all vegetables produced would be bought, if delivered in good condition. Their objections and difficulties were listened to, and, where necessary, further considered on the land and, if possible, removed. They were also informed that Government would look with favour upon those who showed a large increase, while those who did nothing rendered themselves liable to punishment. As far as this threat was concerned no action was actually necessary, though one or two men had to be warned again later on, and one man in particular, who owned an oil engine and pump which he seldom used, was told that if a stated portion of his land was not under vegetables within a given time, his pump would be bought for a price named and sold to a man anxious to use it ; his land was then sown. Two or three other meetings were held at intervals, and care was taken to impress upon all that the matter was to their advantage as well as ours.

The agricultural work resolved itself into constant visits to the men in their fields, and in this I received very valuable assistance from Sergeant Wimshurst. Wimshurst was a student at Wye when war broke out, and enlisted in the 1/5th Buffs, was wounded at the battle of Shaikh Saad, and later employed at the base where he learnt Arabic. He was transferred to me on November 15th 1916 and shortly afterwards promoted to sergeant. Towards the end of 1917 he was granted a commission at my request, and became an agricultural circle officer under the new arrangement. I am glad to take this opportunity of recording his useful work. As he was in Austria in 1914, and only reached Holland on the morning of August 4th, it was unfortunate that the enemy could not be informed

of the potential Turk-killing power (by means of men saved from scurvy) that had slipped through their fingers.

Advice and help was given to the growers, principally with the object of obtaining better results from their existing means, increasing these, and insuring as far as possible a succession of crops. Little help could be afforded in labour difficulties. In this, and similar cases, we could only say (if I may put it so) that, had the campaign been waged in order to provide the force with vegetables, it would have been easy to supply them, but the issue of vegetables was only a small, though momentarily an unduly important item in the business of enabling the campaign to be waged. Comparatively little seed was distributed; the growers were suspicious of Indian seed and preferred their own, which dribbled down from the north. How it came I do not know, nor did I enquire too carefully, lest I should draw undue attention to the fact (the blockade was not my business, and the seed was coming in, not going out), but when it was wanted it usually came. An imported oil engine and pump, which were available at Basrah, were sold to one of the most enterprising of the cultivators and several *noiria* pumps were disposed of in the same way. Wood, which it was almost impossible for the Arabs to procure, was supplied for *chered* rollers and *noiria* gears. A small two-acre garden was started as an object lesson in good clean cultivation. All this caused a substantial increase in the out-turn, which would have been larger had we been able to start earlier in the season, and had the XIII Division not occupied the greater part of the lift-irrigated land on the left bank above the town.

Besides Amarah, similar measures were taken at Ali-al-Gharbi, Mudelil, Qalat Salih and Qurnah. Ali-al-Gharbi, 79½ miles by river above Amarah, and 42 miles below Shaikh Saad, received particular attention and a pump, as it was the most northerly village where Arab cultivation could be used. The total out-turn was much less than at Amarah, as the inhabitants were few, but the proportional increase was greater. Mudelil and Qalat Salih produced enough for their garrisons. Qurnah made a good return, and, when the Qurnah-Amarah railway was opened, sent vegetables to Amarah, which were issued locally and released others for the front.

The following table gives the weight, in pounds, of the fresh vegetables purchased for the troops.

	Previous monthly average	Dec. 1916	Jany. 1917	Feb. 1917
Bought in Amarah ...	210,755 (1)	613,101	490,488	728,335
Out-turn from Amarah Garden ..	Nil	Nil	9,357	7,850
To Amarah from Qurnah ..	Nil	Nil	6,866	173,012
Bought in Ali-al-Gharbi ...	48,388 (2)	120,377	95,804	149,641
Total ...	259,143	733,478	602,515	1,058,838

(1) Average for 6 months April-September 1916
(2) Average for 3 months August-October 1916
There were no records of previous purchases, if any.

It would be interesting to compare these figures with the returns for the cold weather 1915-16, but there were few vegetables and no records then; on the other hand, the out-turn per acre is, on the whole, larger from hot weather than from winter vegetables.

In addition to the work with the Arabs, various attempts were made to encourage direct cultivation by units at all places on the line of communication. The results, however, were small, nor is this to be wondered at under the existing conditions. The marching posts, at intervals of ten miles, were kept busy mounting guard and escorting, and the personnel, both at these and the larger places, was constantly changing. The best results were obtained at some of the hospitals. The first thing done at Shaikh Saad was to get boxes of cabbage seedlings sown by the seven *malis*, to be transplanted into land which two hospitals prepared. At Amarah at least three hospitals had already laid down good vegetable gardens, and arranged for their own seed, others followed their example. By one means or another, a fair amount was produced by direct cultivation, though much seed was unavoidably wasted. Unfortunately I have no definite records of the results, those that I have show that seed was distributed to seventeen hospitals, posts or units,—and there were certainly others.

Collecting.

Formerly vegetables had been purchased through a contractor, and very little enquiry proved that (like most contractors) he made large profits. But it will be remembered that my first proposals demanded prompt payment in cash and the abolition of contractors as an essential part of the scheme; and this was arranged for by what became generally known as the Amarah market.

For this a convenient site was selected in the corner of a yard surrounded by a wall and situated near the river bank, where two open sheds, 84 feet long by 16 feet wide, were erected on an existing earthen plinth, and roughly floored with country bricks. There was no particular reason for these dimensions, except that they suited the available space and material; all that was required was protection from the sun and rain.

The idea was very simple. Previously about 3,000 lb. of fresh vegetables had been sold daily in the bazaar to the inhabitants, and the remainder bought by the contractor and delivered to the S. & T. It was now made a penal offence for anyone who brought vegetables into the town to take them anywhere except into the market, and the police were instructed accordingly. Here they were examined, weighed, and bought at varying prices fixed at monthly intervals. What we did not require, or not less than 2,000 lb. a day, were taken out again and sold in the bazaar to the general public.

It was hoped that the market would have been ready by the end of November, but owing to various delays, lack of labour, scarcity of material (one shed fell in directly the roof was put on: wood had to be imported, so those responsible cut down the factor of safety as much as possible,—and sometimes overdid it), it was not completed until the middle of January, and opened on the 21st of that month. Sub-conductor Costello S. & T. was in charge, with a sergeant and pay clerk under him, and ran it well.

There was one item of the market's furniture that deserves a paragraph to itself: the cash-register. From hazy recollections of London shops, it seemed that a cash-register used backwards, would be some check on the payments. That is, the clerk would start the

day with a fixed sum in the drawer, and on payment being made, the register would be put through all its tricks, ring a bell, hoist the figures, and jot them down on paper, but the money would be taken out, not put in. Accordingly one was ordered. Unfortunately it arrived after I had left for Baghdad, and I never saw it,—I believe the clerk was afraid of it, and it was only used a few times. However, I feel certain that it was the first cash-register in Mesopotamia.

The advantages of the market were obvious. The large profits previously made by the contractor were divided between the government and the growers, to the advantage of both. The vegetables sold in the town were the worst, not the best, as had been the case when the contractor received a fixed price for all. The growers were more careful to bring their produce in rapidly, as damaged goods were paid for at reduced rates. There was little extra expense; the number of coolies employed in packing, weighing and shipping was proportionately the same as that necessary to handle the vegetables when delivered by the contractor, and a sergeant had always superintended this, thus the only permanent extra was the pay of the sub-conductor and the clerk.

The actual figures are as follows :—

Cost of erecting the market, Rs. 4,793-8-0. This was very high, and was due to the excessive cost of the imported material and the inflated wages of labour.

The amount bought from the contractor during the 20 days, January 1st to 20th, was 220,135 lb. The amount bought in the market during the 11 days, January 21st to 31st, was 270,353 lb. That is, an average increase of 13,570 lb. a day.

Had these 270,353 lb. been bought through the contractor they would have cost Rs. 16,897-1-0; but they actually cost Rs. 10,335-8-0, a saving of Rs. 6,561-9-0. The market, therefore, produced more vegetables at less cost, and more than paid for itself in the first eleven days.

TRANSPORTING.

The transport of fresh vegetables from Amarah to the front had not been very successful. They were sent up on a barge which left

twice a week and usually stopped to deliver rations at the posts *en route*. This, in addition to a slow journey, necessitated the contractor and the authorities saving all surplus on the intermediate days, for shipment on the day on which the barge left. The vegetables were packed in sacks or open baskets piled one on the other, and the loss from crushing and delay was very great. An open barge with shelves was first selected, so that the vegetables were not heaped up in one mass, but this was not sufficient. Reports showed that there was still over 50 per cent. loss in transit.

The best course in the circumstances would have been to organize a special service of fast steamers, so that one left each evening carrying the vegetables received that day, properly packed in crates. This, however, was never attained, the real reason being that boats could not be spared. Nevertheless, considerable improvement was effected. Crates were procured from India in planks, nailed together locally, packed in the market and as many of them as possible placed on passing steamers, almost all of which stopped at Amarah. Similar measures were taken at Ali-al-Gharbi. By these means the amount of loss in transit was considerably reduced, though it remained an ever present trouble.

What proportion of the requirements was the 1,058,330 lb. produced in February ? At the end of January the ration strength of the force at Amarah and above was 50,738 British and 90,389 Indians, and the weight of vegetables required during February was, therefore, 2,058,330 lb. of which we were producing over half, in addition there were the vegetables produced by direct cultivation, and those supplied in Mudelil, which are not included. But, as explained above, there was considerable loss in transit, so that, while the XIII Division and the troops on the line received full rations, the men at the front got less than half, and those furthest away less still. Had the position remained unaltered, there would have been a further improvement, during the next season, operations could have been commenced in time ; a Sheik near Ali-al-Gharbi was about to put down a large area ; a Jew was found, who was willing to arrange another large section near Kumait ; pumps capable of irrigating several hundred acres had been ordered for a Sheik near

Amarah. But all these, and other plans, were abandoned on the advance.

II. During the advance.

Everyone knows the chief features of the advance from the Sannayat-Sinn position to Baghdad, and beyond. The steady fighting up the right bank during part of December and January, the Shumraon crossing, the retreat of the Turks, and the entry into Baghdad on March 11th 1917.

An anxious time, probably, for many people, besides the Turks—certainly for the agricultural section. That which one hoped for, yet in one way dreaded, had occurred; the troops were running away from their vegetables, which could not be picked up and carried along behind. The only thing to do was to follow the army up anxiously scanning the banks for likely places for farms, and feverishly cross-examining Arabs as to where vegetables could be obtained. All the replies pointed to Baghdad as the only hope. It all came right in the end—but what if the army had not reached Baghdad?

III. Baghdad and beyond.

Arrived in Baghdad, the first essential was to estimate the vegetables in the neighbourhood; a difficult thing to do with any exactitude. Cultivation of all sorts had decreased during the last two years, and, at the moment, numbers of cultivators had cleared off, through a not unnatural desire to get out of the way of the war. There seemed, however, to be more vegetables on the ground than we had left behind in Amarah—which was so far to the good.

It may be thought that our difficulties had settled themselves; but they had not. In the first place, the quantities grown at Amarah were not enough, as has been shown. In the second place, Amarah was a small town and the requirements of the population comparatively negligible; but Baghdad, on the other hand, was a large town, the inhabitants of which were used to cultivated vegetables and consumed considerable amounts. Again, owing to the needs of the army, and the dislocation of many of the

ordinary channels of supply, certain of their usual sources of food were reduced or almost entirely cut off, while prices rose at once; so that the people were driven more and more to depend on locally grown vegetable food. In fact the scarcity became so great that the military organization had to import grain for the civil population; an additional strain on the long and severely taxed line of communication already burdened with the supply of the force. But that is another story. From our point of view reliable estimates of the vegetables available were at all times almost impossible to compute, for, not only had the constant movements of the troops to be considered, but allowance made for a varying and unknown factor, the requirements of the town.

There were, then, not enough vegetables to supply both the troops and the town, and it was necessary to start again on much the same lines as at Amarah, telling the people that large quantities would be required, and helping them to get those quantities grown. For the moment, however, no one knew who were the owners of much of the land, or where they lived—though the authorities were rapidly finding out. As an immediate step Sir Percy Cox kindly circularized his Political Officers and some of the well-known landholders near. Gradually in one way or another the men were told, and the effort started. Our strongest card was to point to the money made by the cultivators at Amarah, a fact now for the first time plain to the inhabitants of Baghdad. The most cursory enquiry at once brought up the question of the pumps, a difficulty that was always with us. I have said that there were a few oil engines and pumps at Amarah, but, the number being small, it was an easy matter to supply them with oil. At Baghdad, however, there were hundreds dotted along the river banks. In a few months we had over 270 on our list, the majority within five miles above or below the town. The owners of these engines had had increasing difficulty in procuring oil since Turkey joined the war; the price, formerly from one and a half to two rupees a tin, had risen to a Turkish pound. After our occupation there was none, and, unless it were supplied almost at once, crops which were irrigated by the pumps would die. Some of them did die, and others were severely

checked; but luckily the general total slowly rose owing to an increase in the number of *chereds*, and extra sowings by men we supplied with oil.

This sudden demand for oil caused much anxiety. It could be obtained from the Anglo-Persian oil fields below Basrah, but had to be brought up the line, which was already overworked, and its transport would take time. Various temporary measures were adopted. A little was captured in Baghdad, of which I obtained 500 gallons for the pumps. I begged 548 gallons from the Camp Commandant at G. H. Q. I was given 2,000 gallons from the ordinary S. & T. supplies. Then we began to receive larger quantities from the oil *mahalas* coming up the river. But by April 25th only 9,064 gallons had been distributed, as against my estimate of forty to fifty thousand gallons a month required. No wonder the crops were looking bad. It was nobody's fault, of course; even the most exacting would hardly expect an army, at the end of a sudden and rapid advance, to produce on demand large quantities of oil that no one knew would be required.

It was not enough, however, to bring the oil to Baghdad, it had to be distributed to the cultivators. The first 500 gallons were given to a few men present at the time, who I knew had pumps and crops. The next 2,252 gallons were carted to a godown lent by the First Revenue Officer, and distributed, with the help of my interpreter and a small Arab youth who proudly answered to the name of clerk, to men already on our list. The confusion was immense, crowds clamoured round the godown hearing that oil was for sale. Things could not go on like that, but, luckily, as I was endeavouring to get a proper staff, Mr. Wilson of Strick Scott's firm arrived. He had been in Baghdad before the war, and, among other things, had dealt in oil. An agreement was made with him whereby he received and distributed the oil, kept the books and collected the cash, receiving as commission ten per cent. of its cost price to Government. It was only issued to men on our list, and on an order countersigned by the Director of Supply and Transport or myself. This arrangement worked very well until after the period covered by this report, when, with the increase of the

department and the extra men employed, it was possible to make other plans.

Before Mr. Wilson's advent, and even afterwards for a time, I was harassed by crowds of Arabs—varying from the sullen and indignant, through the dignified and grave, to the pathetic and almost tearful—all clamouring for oil. They followed me about, and invaded my room at all hours of the day, and sometimes sat outside at night. For the most part they were quite reasonable, and realized we were doing the best we could. Gradually the lists were completed, and the proportion due to each adjudged.

But our troubles were not over. Even had we had the most perfect methods of distribution we must have had trouble as the amount available did not meet the demand. In April the authorities agreed to supply fifty thousand gallons a month, the quantity then estimated to be enough. By August the requirements had increased, owing to the hot weather, the greater quantity of pumps in use and of land under crops, and the estimate had to be raised to eighty thousand gallons a month. But, far from increasing our supplies, the original fifty thousand gallons could not be delivered. Some actual figures are:—for July, 36,868 gallons; for August, 54,572 gallons; for September, 34,448 gallons. It was obvious that crops were suffering, and discontented cultivators once more appeared. The river was low, oil barges few, and difficult to get up, while extra supplies were wanted, to light the town, work ice plants, for sanitary use. Special efforts were made to accelerate delivery; while soon, owing first to the cooler weather, later to the rain, less irrigation was required and less oil was in demand.

An interesting sidelight was the small amount of water actually necessary to keep a plant alive. I wish I had been able to get figures of water supplied and crops produced—they would, I think, have startled irrigation experts here.

In addition to procuring burning and lubricating oil, it was necessary to provide repairs. Shortly after we arrived, the First Revenue Officer found six men for me who had worked in repairing shops before the war, and an attempt was made to make use of them. It proved impossible to work them as a controlled concern,

spares were difficult to get, and materials were not available for a shop. Again a stroke of luck! An old Arab, an excellent "mistri," was found, who, with a little semi-official help, carried out the work himself. He bought (and, possibly, found) spare parts from those who had them, or whose engines had been broken by the Turks, and collected his own break-down gang. Passes were given to him and his men to enter and leave the town, and belts and spares occasionally bought for him from Works. All the same, clever though he was, he could not manage serious repairs, and his resources steadily became less; so suggestions were made that the repairing work should be undertaken by Works, and in September 1917, a letter was put up to the D. S. and T. making definite proposals. Eventually Works took over the whole, but after the period of these notes.

Most of the pumps were near Baghdad, but there were a few at other places in the forward area and dotted down the line. These received oil from the nearest supply depôt on instructions from headquarters, and the number dealt with thus increased as the country became more settled.

At first our principal agricultural work was in the neighbourhood of Baghdad, but a considerable amount was done at other centres, such as near Baqubah, Fallujah, Samarrah and Ramadie in the forward area, and at or near almost every station down the line. The methods adopted were much the same as those already described at Amarah, and our object was to get the Arabs to grow the requirements themselves.

Sergeant Wimshurst came to Baghdad in May; and Lieutenant Cheesman ably superintended the work on the lower L. of C. after the Madras garden corps arrived and relieved him of the Shaikh Saad farm.

A particularly neat arrangement was carried out with the help of the VII Division at Samarrah, whereby cultivation was encouraged in their area, and even beyond our lines, in spite of the presence of two hostile armies. Major MacMahon, their D. A. A. and Q. M. G., took a lot of trouble over this. The XV Division, with Lieutenant Cheesman's advice, did much to encourage production at Nasiriyah,

and later at Ramadie. In fact, once the methods were explained, the work was taken up on all sides.

The most unfortunate place, and the one most difficult to supply during the hot weather, was Basrah. Efforts to increase the cultivation of vegetables in that neighbourhood did not meet with much success, owing to labour difficulties and probably to lack of expert advice. It should have been possible to make up their deficiencies with vegetables from Amarah and Qurnah but, with the transfer of Sergeant Wimshurst and myself to Baghdad, the purchases in these places fell off considerably (February, 901,347 lb.; March, 658,280 lb.; April, 332,920 lb.; May, 504,000 lb.), while proper arrangements, apparently, were not made for sending the supplies down stream. Later, however, I transferred Lieutenant Cheesman to Amarah to reorganize the supply.

Gardens run by the troops themselves seldom reduced the ration demands, principally because a unit rarely remained in one place for a sufficient length of time; but three gardens in particular gave good results, at Nasiriyah, Fallujah and Ahwaz, while small amounts were produced at Diyalah, Ctesiphon, Baghailah, Aziziyah and elsewhere. Vegetable seed was given to all units on demand until September 1917; but then free seed was no longer necessarily supplied to units in places where sufficient vegetables were known to exist. The following amounts, in pounds, were issued (the figures in brackets are the weights received from India):—Beans, broad 1,547 (5); beans, French 71 (60); beans, haricot 1 (5); beans, kidney 814 (0); beetroot 473 (379); brinjal 345 (57); cabbage 112 (295); carrot 249 (113); cauliflower 33 (114); chillie 38 (23); cucumber 1,333 (152); gourd 407 (414); kohl rabi 34 (38); lady's fingers 1,305 (604); lettuce 61 (21); melon, rock 18 (18); melon, sugar 275 (0); melon, water 878 (30); onion 1,063 (95); peas 52 (59); pumpkin 112 (57); radish 601 (6); spinach 773 (314); tomato 120 (25); turnip 407 (133).

The above are the majority of the seeds distributed direct, and were supplied to units, Arabs (most of whom, however, found it cheaper to procure their own), and our own farms at Shaikh Saad and Baghdad.

The seed sent from India had a long and difficult journey, and the germination of a few of the samples that arrived was *nil.*

As against this, however, it became more and more easy to obtain seed in the country (some of the varieties were called Damascus and some Stamboul—whether or not they really came from there I do not know); and, on the whole, the country varieties did better than the Indian.

The Shaikh Saad farm, as recorded above, was fifty acres, taken up immediately after I came out. When I first left there for Amarah, Lieutenant Cheesman, I.A.R. (formerly of Wye, and then 1/5th Buffs), was detailed as my assistant and went to Shaikh Saad to organize the farm, arriving there on October 26th 1916. He had many difficulties to contend with, due to scarcity of labour; but gradually implements, a pump and a small staff (an Indian officer, 3 British privates, about 30 Indians and 24 bullocks) were collected, and at the end of the year I was able to send him Sergeant Aldridge, an excellent practical gardener, also of the 1/5th Buffs (the agricultural section might almost be described as an offshoot of the Buffs—proving the prowess of the men of Kent in agriculture, in addition to other directions!). Much spade work had to be done before the farm began to produce; its first returns were 402 lb. in March and 3,980 lb. in April 1917. The difficulties were reduced when the Madras garden corps arrived in May.

This corps, if I remember rightly, was first offered by Madras in November 1916. Under the then conditions, I suggested that enough men be asked for for the Shaikh Saad farm and a similar farm at Arab Village or elsewhere; and a telegram to that effect was sent. The personnel eventually despatched was 2 British officers, 2 British N. C. O.s, 1 sub-assistant surgeon, 1 clerk, 4 head *malis,* 24 *malis,* 220 coolies, 3 *bhisties* and 3 sweepers. Unfortunately they were only enlisted for a year, and did not arrive until May 1917, when the conditions had entirely changed. I placed about half at Shaikh Saad, and the remainder on a farm at Baghdad. They produced good crops while they were out, but left in February 1918 on the completion of their year. The figures of the cost of the vegetables they produced proved the wisdom, even from economy alone, of

confining our efforts, wherever possible, to production by the Arabs. For example, the cost of the vegetables produced on the Baghdad farm, from the time of the arrival of the corps on May 24th, to the end of September (excluding the cost of rations, tents, clothing, implements, seed, et cetera, and 3½ months' pay while coming out) was 2·3 annas, as against the contractor's price of 0·88 anna a pound.

Fruit, with the exception of melons, was beyond the powers of the agricultural section. There were fruit trees (oranges, limes, mulberries, apricots, figs, pomegranates, each in their season, in larger or smaller quantities) at Baqubah, Baghdad and elsewhere; but it was useless to try to increase the immediate supply, and improvements in pruning and so forth could only have been introduced slowly by a large staff. It was possible, however, to increase the area under melons, and this was done. The ration was 2 oz. daily of fruit, either fresh or tinned.

Notwithstanding the success of the Amarah market, the new purchasing department was averse to starting similar concerns elsewhere—at Baghdad, I believe, because of the size of the undertaking, and at other centres, because the position had become easier, and contracts were preferred.

Transport difficulties were considerably reduced. The troops were spread out, instead of concentrated in one spot; while railways from Baghdad to Samarrah, Baqubah and Fallujah, combined with motor transport, rendered the distribution comparatively easy, especially as each centre became more nearly self-supporting.

Results.

The following table gives the quantities in pounds purchased and supplied from the larger farms:—

Month 1917	Line of communication	Forward area	Shaikh Saad farm	Baghdad farm	Total
April	640,920	713,720	3,980	nil	1,358,620
May	909,440	892,080	7,963	nil	1,809,483
June	1,624,840	1,514,240	25,065	nil	3,164,145
July	1,906,520	2,054,640	46,773	1,829	4,009,762
August	1,958,600	2,173,640	47,000	61,893	4,241,133
September	1,942,080	2,705,360	57,647	79,391	4,784,478
October	1,828,160	2,551,640	50,219	76,536	4,504,555
November	1,294,440	2,174,200	79,960	23,135	3,571,735
December	2,336,575	2,556,794	149,759	27,139	5,070,267

The rise in the above returns for June may fairly be taken as proof of the efficacy of the work in and around Baghdad and on the upper L. of C., from the time of the capture of the town. The contractors began to deliver our full requirements in Baghdad from about May 25th.

The following table shows the relation between the vegetables supplied, and the amounts required for the daily ration of 12 oz. for British and 6 oz. for Indian ranks :—

Approximate ration strength on (1)	British	Indian	Weight required during the month, pounds	Weight supplied, pounds	Excess (+) deficit (—) pounds
September 1st ...	88,965	238,405	4,683,768	4,784,478	+100,710
October 1st ...	101,305	265,562	5,442,499	4,504,555	—937,944
November 1st ...	107,785	278,420	5,557,387	3,571,735	—1,985,652
December 1st ...	121,773	315,128	6,494,585	5,070,267	—1,424,318

(1) The ration strength is the whole Expeditionary Force, including Medical, I. W. T. Labour corps, followers, et cetera.

Under conditions such as described, a renewed shortage was almost inevitable when the force was increased (in terms of vegetables required), by nearly 40 per cent. ; but the supply was gaining again on the demand by December, and the shortage was never as bad as it seemed, for two reasons. Firstly, when massing the figures in this way, no account can be taken of those troops who, owing to operations, movements, and so forth, could not be supplied temporarily ; but their numbers were sometimes large. Secondly, the potatoes and onions imported from India are not included. I have not got any figures here, except those showing that in December 785,557 lb. of potatoes and onions (more than half the deficit) were issued on the lower L. of C. alone, from Basrah to Kut inclusive.

There was another amusing proof that the vegetable position was practically secure. In the early days the average man was delighted if he received a somewhat damaged turnip, or even wilted turnip tops. Towards the end of the time complaints began to be heard. "We do not want lady's fingers, we do not like them, and we are tired of brinjals too," said the army, in effect, "why not give us cauliflowers or cabbages or peas ?" Or later, in the cold

weather, " nothing but turnips "— or beetroot, or lettuce, as the case may be. It was little use explaining that cauliflowers or peas could not be grown in the hot weather, or that it was necessary to concentrate on the higher yielders among the vegetables known to the Arab,—they simply did not believe you. And personally I sympathized, I never liked hot weather vegetables myself.

The ultimate test for the results, however, must be sought in the scurvy returns, as the principal reason of the ration was its antiscorbutic effect. This is shown in the table below which compares the numbers of scurvy cases admitted into hospital for the whole force during the hottest months of 1916 and 1917.

Month	Number of cases 1916	Number of cases 1917
July ...	2,465	339
August ...	3,395	211
September ...	2,990	168

During this time the ration strength had approximately doubled, the proportion of admissions, therefore, had fallen by over 95 per cent. A proof that the vegetable ration was the chief, though not the only, means for combating the disease, is that 46 per cent. of the remaining cases occurred in Basrah, the place most undersupplied.

SOME FACTORS WHICH INFLUENCE THE YIELD OF PADDY IN COMPARATIVE MANURIAL EXPERIMENTS AT THE MANGANALLUR AGRICULTURAL STATION.*

BY

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THE Manganallur Agricultural Station is situated in the Tanjore delta, and is devoted to the study of wet land or swamp paddy. This crop is grown in fields enclosed by earth "bunds" or ridges to hold in the irrigation water, and the fields are each about one acre in extent. The soil is a heavy clay, such as one would expect from deposition of fine silt in standing water. Analyses show that 65 per cent. of the soil consists of clay and fine silt.

The following outlines the method of cultivating the crop. The sprouted seed is sown in a manured seed-bed, which is prepared by ploughing under water (puddling) and carefully levelling with a board. Shallow drainage channels are made at intervals across the seed-bed to drain off superfluous water. When the seedlings are about 40 days old, they are pulled out and carried to the field which has been prepared by puddling and levelling, and here they are singly planted out at intervals of about 9 inches. In a few days these strike fresh root, and subsequent operations consist of weeding

* This article was originally intended for the Madras Year Book, but the writer felt that this question of the study of field experiments, not only in the case of manurial experiments with paddy, but with practically all field experiments, was of such importance that it might gain wider publicity in the *Agricultural Journal of India*, and that other workers might reciprocate in giving their experience of similar observations in the case of other crop experiments in India. [H. C. S.]

once, or twice if necessary, and regulating the supply of irrigation water which is maintained at a depth of 3-4 inches. Irrigation continues until about two weeks before harvest, when the water is drained out and the field is allowed to dry.

Manurial experiments are of two types. Those which are designed to test the effect of a manure on the succeeding crop *i.e.*, a single application of manure, the results of which are recorded in the yields obtained, and the experiment is concluded. In the other type, the same manure is annually applied to the same plot to ascertain the cumulative effect of the manure. In this latter case one has not only to compare the yields obtained in the one year but also to compare the yields obtained in one year with those obtained in another.

If such experiments were absolutely under control, then the results obtained from duplicate or multiple plots under the same treatment should always agree in any one season, and it is these factors which cause variation in yield between plots receiving the same treatment and which are now under discussion.

The first type of experiments, namely, those concluded in one season, is likely to give much more accurate results, but they give much more meagre information, and their scope is strictly limited. Many more factors in this case are under control.

The seed used in the seed-bed is the same. If the seed-bed is properly prepared, and if seedlings along the margin and the drains are not used, it is possible to get seedlings all of the same age and quality. The planting of all the plots can be completed in the same day. Irrigation and surface drainage are the same. It will, however, be found that no two plots under the same treatment will ever give the same yield, and if the experiment were repeated the following year on the same field, it would be found that the results obtained would be different from those obtained in the previous year. These differences in yield are due to factors which are beyond control.

In the first place, it is impossible to get land of even fertility, and this is more difficult probably in the case of swamp paddy than with any other crop. When the land is ploughed under water, a

great proportion of the debris of the previous crop floats to the surface, and the wind will blow this to one side of the field. If there are regular prevailing winds, then the side of the field opposite the direction of this wind is always more fertile. In this case the south-west monsoon winds are blowing when the fields are ploughed, and the north-east side or corner of the field is always the most fertile. Such crop debris is also apt to clog on the plough, and where this drops off or is removed, the soil is enriched at that spot. In levelling the field the surface soil is drawn from the higher to the lower levels of the field, and, when level, such portions which were originally lower are inclined to be more fertile. The texture of the soil is also affected by irrigation. Around the water inlet, where the flow of water into the field is rapid, much more coarse soil particles are deposited, while the farther away from the inlet, the less will be the flow and the finer will be the sediment deposited. Thus. even though care has been taken to standardize the field by harvesting the previous crops in small areas, a further error is always liable to creep in from the ordinary cultivation operations in the field.

Weeds again are another source of error. If the field is not uniformly levelled, and the water is not kept to a sufficient depth in the field, rushes, sedges and other semi-aquatic weeds are bound to spring up wherever the soil is exposed. The debris blown to the side of the field also contains large numbers of weed seeds and *Marsilia coromandaliana* may be mentioned as one which is often troublesome. " Veppam pasai " (Tam.) [*Chara*, spp.] is also a very troublesome aquatic weed which may greatly check the growth of the paddy. This is much more likely to affect the unmanured or check plots, because these are always backward in becoming established, and this weed which requires full sunlight will often get a hold here, while on the manured plot it may be suppressed. When once it has got a firm hold it is very difficult to eradicate, and as it keeps the growth of the crop in check, it will materially lessen the yield. Thus the difference in the yield of the manured and the unmanured plot may be much greater on this account than if this weed were not present. It may be said that such difference should

be credited to the manure. In ordinary farming it can be, but in an experiment it must be discounted, because there is no guarantee that every field has this weed present.

The season also may affect the yield of different plots. Heavy rains in the fallow period will cause these lands, which, when dry, have cracked both widely and deeply, to swell and more or less completely close these cracks. This is disastrous to the succeeding crop as it stops drainage and soil water movement through the soil ; not only this, but the soil below the surface becomes so compact that the roots of the crop are unable to use any but the surface soil. The efficiency of the cultivation is greatly decreased and only a shallow puddle can be procured. These delta soils though very uniform near the surface vary very considerably in depth. Those on this Agricultural Station rest on coarse river sand which may be a few feet or many yards from the surface. It is obvious therefore that the deeper the clay alluvium, the more disastrous are the effects of this check in drainage. In this way even parts of the same field may be affected differently. The same result occurs when irrigation water is let into the field and the field is then allowed to dry. If the water is kept continuously on the field then the drainage is not adversely affected.

The season may also affect the development of the grain. It has already been pointed out that the manured crop will often become established more quickly than the unmanured fields, and these naturally come into ear sooner. For example, a crop manured with superphosphate will invariably come into ear a few days sooner than a crop which is unmanured. A heavy rain at the flowering time will affect the setting of the grain, and one plot may suffer while the other escapes. In the same way a rain at harvest time may cause one of the crops to shed more than the other.

The question of the crop being laid may affect the yield. The straw of these delta paddies is invariably weak, and a manured crop, especially if manured with nitrogenous manures, may be badly laid, sometimes even before it has come into ear. Unmanured plots on the other hand will often remain standing until cut. If a crop is laid before the water is drained off the field, some of the

grain invariably gets damaged. Even if it is laid after the water is drained and the weather is dry, much more grain is shed during the operation of harvesting than is the case with a standing crop.

To ensure the greatest accuracy, therefore, it is necessary not only to multiply the number of plots receiving the same treatment and take the average results, but it is also necessary to repeat the experiment for several seasons and take the average of these. This, however, would involve a very large area of land, as it is obvious that a fresh area would have to be selected each year for each experiment on account of the manurial residue left in the soil.

The majority of manurial experiments, however, deal with the cumulative effect of manures when annually applied to the same plot. The type of experiment already discussed, deals only with the effect of quick-acting or soluble manures which show their results on the succeeding crop, and the causes which affect the yield of continuous experiments on the same land, besides including all and accentuating many of those already discussed, introduce many new factors which affect the yield. During the same season the control is just the same, but comparing the yields from season to season, only three factors can be definitely controlled, *viz.*, the shape and area of the plots, the quantity of manure applied, and the actual weighments of grain yield. Straw yields cannot be controlled, as the moisture content varies with the ripeness of the straw and the state of the weather. The seed may be of the same variety, but it may be of different quality, *i.e.*, germinative energy and capacity. The seedlings may be of different quality and age. The season may be early or late. If it is late, the effect of the manure, especially phosphatic manure, will be more marked, because late planting always affects the yield, and the crop becomes established sooner and matures sooner when manured with phosphates. The physical soil conditions, however, vary very much from season to season, and if the drainage is bad and the puddle shallow, very little effect of manurial treatment will be seen.

In the case of many manures, especially bulky organic manures, these in themselves greatly alter the texture of the soil, and the cumulative effect in this respect is often very marked and apparently

very variable. The effect of other manures applied in conjunction with such organic manures also varies greatly. For example, where an organic manure has been able to improve the texture of the soil, so that the season effects of poor physical drainage are counteracted—this may occur if the alluvium is not too thick—then other manures applied in conjunction with the organic manure may show marked increase in yield. If, however, the alluvium is deep and only the texture of the surface has been improved, a bulky organic manure is, under these anaerobic conditions of cultivation, liable to turn the soil acid. An acid manure, such as superphosphate, would in this case very probably do more harm than good in that particular plot, while the organic manure itself might also show a decrease in yield when compared with the check plots. The residual value of the manure in the duplicate plots would, however, be very different, and if in the next year the physical conditions of both plots are good, the yields will vary greatly.

It is thus evident that if plots are merely duplicated, it is impossible always to draw conclusions merely by studying the figures of yield. One plot may show an increase, while its duplicate may show a decrease. The continuance of the experiment over a number of years will give an average, but it must be remembered that the cumulative effect of the manure has also to be taken into account. The solution of the difficulty seems therefore to be in multiplying the number of plots under the same treatment and averaging the results.

Another factor which seems to be an insoluble difficulty in such permanent experiments is the formation of the plot or unit of experiment. There are two methods of doing this. Firstly, each plot may be separated from the next by a permanent earth bund or ridge; and, secondly, each plot can be marked by permanent stones and separated from the next plot by an unmanured strip. Neither of these ways is perfect. The objections to the former are :—
(1) It is difficult to get uniform cultivation and levelling. (2) Each plot has to be irrigated and drained separately. (3) The margins of the plot will invariably show better growth. (4) The crop is much more exposed to attack of crabs and caterpillars which the

permanent earth bunds will harbour. (5) Unless these bunds are high, they are very liable to break down during the cultivation season and not hold the water in the field. They are often submerged during heavy rains. If the bunds are high, the crop is not under normal conditions, as it is too much protected from the wind, and the soil from the bunds is continually being washed down into the field from which it has again to be lifted in the next season when the bunds are repaired. High bunds also leak very badly, as they harbour crabs and rats which riddle these with their tunnels.

The latter method is preferable on the whole because, (1) observation shows that soils, even under these swamp conditions of cultivation, receive and retain manures as soon as they are applied. Nitrates are an exception, but these do not come within the scope of manurial experiments with wet-land paddy. There is therefore little, if anything, to be gained in this respect by providing earth bunds. (2) It is possible to puddle each plot as a separate unit, but unfortunately it is not possible to level each plot separately, as the whole field has to be of the same level; there is therefore always a certain amount of mixing of the surface soil in the plot with the surface soil adjacent to it, and the residual value of previous applications does not entirely remain in the plot to which the manure was originally applied. Observation shows that this effect is apparent in the growing crop to a distance of 5 to 6 feet from the margin of the plot. It is necessary therefore to leave a non-experimental strip of at least this width between plots. (3) As regards irrigation, drainage, weeding, etc., conditions are uniform for all plots; while the danger of loss from the insect and other pests is minimized.

What has been written indicates the importance of maintaining careful observation notes of experiments and the danger that lies in merely judging the results of different plots by the figures of yields recorded. There are so many factors which induce error, and which are beyond control, that without such observation it is often impossible to draw any deductions of value from the yield figures recorded. Much has been written about the importance of estimating the probable error of an experiment. In any experiment concluded in one season this must form the basis of the value of the

results obtained; but in a continuous experiment conducted over several years on the same plots, there are so many factors which alter the original condition of the plots and so many factors which vary from season to season that, after the first year, the only method of gauging the value of the yields obtained is by the study of the growing crop in the field.

EXPERIMENTAL ERROR IN VARIETY TESTS WITH RICE.

BY

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INTRODUCTION.

ALL work on the improvement of crops, whether by the introduction of new varieties or by plant-breeding, requires constant comparisons to be made with regard to yield. Where large numbers of strains are being grown for comparison any increase in the accuracy or rapidity with which undesirables can be rejected results in a correspondingly increased efficiency in the work. A study of the experimental error involved in different methods of making these comparisons is, therefore, of the utmost importance, since the knowledge obtained makes it possible to handle, with any required accuracy, the maximum amount of material for a given set of conditions or resources.

During the last ten years, numerous investigators have drawn attention to the importance of experimental error in all types of agricultural experiments. This has had its effect in improving, very considerably, much of the work that is being done. There is still, however, room for improvement in a good deal of the work of which accounts are published.

It is not proposed to discuss the literature on this subject. Lists of references will be found in papers by Hayes and Arny[1] and Batchelor and Reed.[2] These include work on a large variety

[1] Hayes, H. K., and Arny, A. C., *Journ. Agric. Res.*, vol. XI (1917), no. 9, p. 399.

[2] Batchelor, L. D., and Reed, H. S. *Journ. Agric. Res.*, vol. XII (1918), no. 5, p. 245.

of crops, including fruit trees, under very varying conditions. The systems adopted by different workers, for reducing the experimental error to any required degree, vary very considerably according to the type of experiment, *e.g.*, whether manurial or variety tests, the quality and quantity of land available, the crop under experiment, etc.

It is proposed in this paper to refer briefly to experimental error in general, under Indian conditions, and to give, in some detail, the results of work on rice in Madras Presidency.

Experimental error in India.

The experimental error of ordinary field-plots has been calculated by different workers for various types of cultivation in different countries. Although there is not as much variation as might be expected for the widely varying conditions involved, it would be impossible to apply any one figure to a given set of conditions without some preliminary investigation.

In order to get some idea of the range of error for various types of cultivation in different parts of India, an examination was made of the results of experiments given in the farm reports of different provinces. The *probable error* was worked out from the yields of duplicate plots as given in these reports. It was very common to find two distinct *series* of plots, of obviously different cropping value, described as *original* and *duplicate* respectively. Results from such separate series were carefully excluded. Apart from this, the figures employed were not in any way selected but were taken at random from any experiments that included a number of duplicates.

This is the same method as was employed by Wood and Stratton[1] in the case of results published in England. It should be noted, however, that the method of calculation employed by these authors (*l.c.*, pp. 436–7) is subject to a definite error. For each pair of plots they calculate the mean and the difference between each plot and the mean. These differences, after reducing to percentages of the mean, in order that the results of different experiments

[1] Wood, T. B., and Stratton, F. J. M. *Journ. Agric. Science*, vol. III (1910), p. 417.

may be combined, they then use for the probable error determination in the same way as they would use differences from the mean of a large number of determinations. In other words, they take differences between duplicates as twice the difference of one from the mean. Now the probable difference between any two results taken at random, such as duplicates, is $\sqrt{2}$ times the probable difference of any one from the mean. It is obvious that, in calculating the probable error from the results of duplicate plots, the difference between any pair should be taken as $\sqrt{2}$ times the difference of one from the mean. Their result for 400 pairs of plots, *viz.*, 4·2 per cent., should, therefore, be multiplied by $\sqrt{2}$, thus giving about 6 per cent. as the probable error for one plot, or 8·4 per cent. for the difference between two plots.

Except for this modification, the same "least square" method of calculating the probable error was applied. The results were worked out as the *probable error of the difference between two plots*, as it is such differences that most experiments are designed to show. As was to be expected, much variation was found when each set of experiments was taken separately. A critical examination of the figures, however, showed much about the same range of error for the different sizes of plots, about 4 to 25 cents, and for different localities. Table I shows the figures obtained for four of the most important crops, representing widely different types of cultivation.

TABLE I.

Probable error of ordinary field-plots in India.

Crop	No. of pairs	% Probable error between two
Rice	240	13·0
Sorghum	166	14·8
Cotton	114	12·2
Wheat	114	14·0
Combined result ...	634	13·5

The results for the different crops show surprisingly little variation. The combined figure, 13·5 per cent., for the probable

error of the difference between two plots, is not very satisfactory, being very much higher than the corrected figure of Wood and Stratton already referred to, *viz.*, 8·4 per cent. for ordinary experiments in England. It must be remembered that this figure is an average result, and there must be, as indeed the details show there are, many experiments with an error much higher than this.

Work on rice in Madras.

A detailed study of this subject has been made in connexion with work on rice in Madras. The probable error has been worked out for different sizes and shapes of plots varying from ordinary field-plots of over one-tenth of an acre down to lines of 20 plants.

Ordinary field-plots.

Under this heading are included such experimental plots, ordinarily in use on the farms, as have not been laid down in the form of specially long narrow strips. Table II gives details for a number of separate experiments on various farms.

TABLE II.

Probable error of ordinary field-plots of rice in Madras.

Farm	Experiment	No. of plots	% Probable error between two
Coimbatore ...	Standardisation N Block	20 plots	13·0
,, ...	Pattimannu manurials	21 pairs	13·4
,, ...	Age of seedlings	8 ,,	13·6
Samalkota ...	Cyanamide manurials	20 plots	13·9
,, ...	Spacing	22 pairs	7·7
Palur	Bulky manures	72 ,,	11·3
Manganallur ...	Phosphate manurials	20 ,,	12·6
,,	Udu manurials	60 ,,	13·9
	Combined result	203 pairs 40 plots	12·3

The results are very uniform with the exception of one experiment, a spacing experiment at Samalkota, which, for some reason unknown, is very distinctly more accurate than the others. The

low figure for this experiment reduces the combined result to 12·3 per cent., though the other results suggest that about 13 per cent. would be more representative of ordinary conditions.

Long narrow field-plots.

Under this heading are included plots specially laid down in the form of long narrow strips with a view to reducing experimental error. They are large plots such as can be used for the majority of ordinary farm experiments, and are in quite a different category from the small strips, to be described later, for use only in variety trials. Table III gives data for a number of series of such plots.

TABLE III.

Probable error of long narrow field-plots.

Farm	Experiment	Area in cents	Dimensions	No. of plots	% Probable error between two
Coimbatore ...	B. Standardization	About 10	Length more than ten times breadth	18	6·0
Manganallur* ...	Fish	5		14	7·0
Do. * ...	Super	5		14	5·5
Do. * ...	Standardization	5	20 × 250 lks.	28	8·7
Do. ...	Do.	2·4	20 × 120 lks.	35	5·7

* For the figures on which these results are based I am indebted to Mr. Sampson.

It will be seen that the probable error of these plots is consistently lower than that of the ordinary plots, shown in Table II, by a considerable amount. It is obviously desirable that such plots should be adopted more generally where the nature of the experiment permits. A large departure from this type would very seldom be necessary.

Lines and small plots for variety-tests.

In working with transplanted rice it is comparatively easy to obtain a full stand of plants very evenly spaced. It was considered, therefore, that the method of testing strains by means of lines or narrow strips would be particularly useful for this crop. Experiments designed to test this have been carried out during several years, and have yielded some interesting results.

The first experiment was carried out, during two successive years, on the ordinary experimental area of the Central Farm, Coimbatore. The method was to divide a field, planted uniformly with one variety, into a number of very small units of regular size and shape. These units were harvested separately and their grain stripped by hand and weighed. It was then possible, by various combinations of units, to compare the yields of small plots of various sizes and shapes.

In 1913-14 one field was used, and in 1914-15 the same field again together with a neighbouring field of about equal area. These fields were planted very evenly at 9 inches apart each way. In each case, after removing a number of lines round the outside, a block of plants was obtained comprising 80 lines with 70 plants in each. The unit adopted was a double line 10 plants long, *i.e.*, 20 plants. The block was divided so as to give 7 columns each containing 40 units lying side by side.

The probable error was calculated for various combinations and arrangements of these units, each field being taken separately. It is not proposed to give the figures in detail but only the main results with the figures for the three fields combined. In the tables that follow the figures representing the size and shape of the plots indicate the *length* and *breadth*, respectively, *in plants nine inches apart each way.*

Some results for plots of various sizes and shapes are given in Table IV, which shows the probable error of the difference between two plots—(*a*) *adjacent*, (*b*) *any two at random*—in the same field.

TABLE IV.

Plot	Probable error between two		No. of plots
	(a) Adjacent	(b) At random	
10 × 10	6·5	10·3	168
50 × 2	3·1	6·8	120
20 × 10	5·5	9·2	72
50 × 4	3·3	6·4	60
20 × 20	5·4	8·5	36
50 × 8	4·0	6·1	30

The long narrow plots are very distinctly more accurate than those that are square or more nearly so. In all cases the error is much less for adjacent plots than for any two at random. This difference, as might be expected, is much more marked in the case of the very narrow plots.

In a repetition series, where several strains are repeated in an orderly manner, so as to give a regular distribution of each over the whole area, the relative accuracies of different types of plot may not be the same as for comparisons of single plots.

Another point of interest also arises. In ordinary practice it is often necessary to compare together, or with a standard variety, a large number of strains. It is a matter of importance to know, for whatever system is adopted, whether the accuracy is affected by the number of strains included in one series. Is a repetition series of few strains, with the different plots of each strain comparatively near together, more accurate than one in which the plots are more scattered, through the inclusion of a large number of strains ?

In order to throw some light on these points calculations of the probable error were made for arrangements representing repetition series of various numbers of strains. Thus for two strains alternate plots were taken together for the required number of repetitions, for seven strains every seventh, etc. Table V gives the results of such repetition series for several types of plot.

TABLE V.

Plot	No. of repetitions	% Probable error of difference between two			
		2 strains	7 strains	14 strains	28 strains
10 × 2	5	3·8	3·5	4·2	4·7
10 × 4	5	2·7*	3·5	3·8	4·1
10 × 10	4	3·2	3·5	3·7	...
10 × 2	10	2·6	2·5	3·1	2·8
10 × 4	10	1·9	2·5	2·4	...
10 × 2	20	1·9	1·7	2·3	...

With regard to the number of strains in one series, the results are somewhat variable but, on the whole, it appears that with a large number of strains the probable error is increased, though only to a relatively small degree. This, of course, applies only to the

special conditions of this experiment where the plots were small and each series was confined to one field.

As regards type of plot, the results indicate little material difference between plots 10 × 2, 10 × 4, and 10 × 10. What difference there is, is in favour of the broader plots. It may be noted that the figure marked with an asterisk, in the 10 × 4 results, is probably too low. In this case one field, of the three of which the combined results are given, gave a much lower figure than the other two, thus reducing the combined figure. The inference is that this figure is less reliable than the others, with which it does not agree very well, and that it would probably fall into line with them if further trials were made. The same applies to the figure for ten repetitions of the same plot and arrangement.

There is obviously no point, so far as accuracy is concerned, in reducing the width of the plot to as little as 2 plants. Anything from 4 to 10 plants wide should be satisfactory for repetition series.

A comparison of Tables IV and V shows, on the whole, very similar results. Thus single plots 50 plants in length, adjacent, give about the same results as 5 repetitions of plots 10 plants in length. There is a slight difference as regards width of plot; in the single long plots the narrowest are slightly more accurate, whereas in the repeated short plots the variation, which is less distinct, is in favour of the wider plots.

An attempt was made to employ plots 50 × 2 plants, with 9 inch spacing, in actual practice, but it was a failure as the stand was ruined by an exceptionally bad attack of crabs. It is obvious that in such small accurately spaced plots a few blanks will materially affect the results. Though a very even full stand can generally be obtained, there is always a fear that crabs may do some damage, as occasional attacks have been experienced both at Coimbatore and in Tanjore. It was therefore decided to try rather larger plots, modified so as to do away with such accurate spacing, but maintaining the long narrow shape.

A preliminary trial was made on the Manganallur Farm in Tanjore District. Three widths of plots were used, *viz.*, 5, 10, and 20 links; they were all 120 links in length. Interspaces of one link were

left between the plots, which were planted right up to the edge of the interspaces. No definite spacing was done but the inside of the plot was filled up by ordinary planting at about 6 inches apart. The results obtained from a number of plots of each width are shown in Table VI as the probable error of the difference between *any two* plots in the same field.

TABLE VI.

Plots 120 *links long.*

Plot width	% Probable error between two	No. of plots
5 links	5·8	42
10 ,, ...	5·3	26
20 ,, ...	5·7	35

There was little difference between the three widths, showing that this factor might be made very largely a matter of convenience with regard to planting, harvesting, area of land available, etc.

Further trials were made, on the Central Farm at Coimbatore, with plots 50′ × 4′ with 1′ interspaces. The planting was roughly 6″ apart, giving 9 lines to each plot. The spacing was not done accurately, by measurement, but 9 lines were planted between strings placed 4′ apart, the outside lines touching the strings. Seven fields were planted in this way, and the probable error for the difference between *any two* plots in the same field is shown in Table VII.

TABLE VII.

Plots 50′ × 4′.

Field	No. of plots	% Probable error between two
1	16	6·4
2	13	5·1
3	11	8·6
4	11	6·8
5	13	8·2
6	14	5·8
7	12	5·5
Combined	90	6·5

The results for the separate fields are as uniform as could be expected for such small numbers of plots, and the combined figure for 90 plots, 6·5 per cent., may be taken as sufficiently accurate for such plots at Coimbatore. The combined figure for *adjacent* plots is 4·2 per cent.

Further results were obtained from actual trials of strains, carried out on the Paddy Breeding Station, in which plots 50′ × 4′ were employed. Each strain was repeated twice in a number of fields. In calculating the probable error the two plots of a strain in the same field were taken as duplicates. By working the differences as percentages it was possible to combine them into one lot and get a figure for the series as a whole. Table VIII gives the results for three such series. They agree very closely with those of Table VII.

TABLE VIII.

Plots 50′ × 4′ in actual trials.

Series	Pairs of duplicates	% Probable error between two
III, 17-18	29	6·2
IV Do.	49	5·9
VII, 18-19	27	6·9
Combined	105	6·6

It is desirable, where possible, to repeat each strain at least twice in every field; a check on the results can then be exercised by calculating the probable error as above. From the point of view of accuracy of the experiment, however, this is not necessary, but each strain should be repeated the same number of times in any one field as this avoids the variation in cropping power of different fields.

The above results for 50′ × 4′ plots (Tables VII and VIII) compare very favourably with those for the small regularly spaced plots of 50 plants in length (Table IV). There are several practical advantages in favour of the former, and for the present these 4′ wide plots have been adopted on the Paddy Breeding Station at Coimbatore. This is a convenient width for one cooly to work both in planting and harvesting; strict supervision is easy and

the work can be carried on rapidly, an important point where large numbers of strains are dealt with.

The length employed varies, according to the size of the field, from 40′–60′, the number of repetitions being adjusted accordingly and varying from about 8 to 12. The area required for each strain is about 5 cents excluding the borders of the field. Any number up to eight strains are included in one series.

The accuracy of such tests has been worked out in a number of cases. The probable error of the difference between any two plots was calculated from the figures for duplicate plots in the actual experiment, as for Table VIII. This figure was then divided by $\sqrt{n}$, n being the number of repetitions, to get the probable error of the difference between any two strains. Six out of seven results lie between 1·9 per cent. and 2·4 per cent., the seventh being 4·0 per cent. All these were on land that had been under observation for only about two or three years. On thoroughly known and selected land it should be possible to work the above system with a probable error of about 2 per cent.

THE "FRASH" (TAMARIX ARTICULATA).

BY

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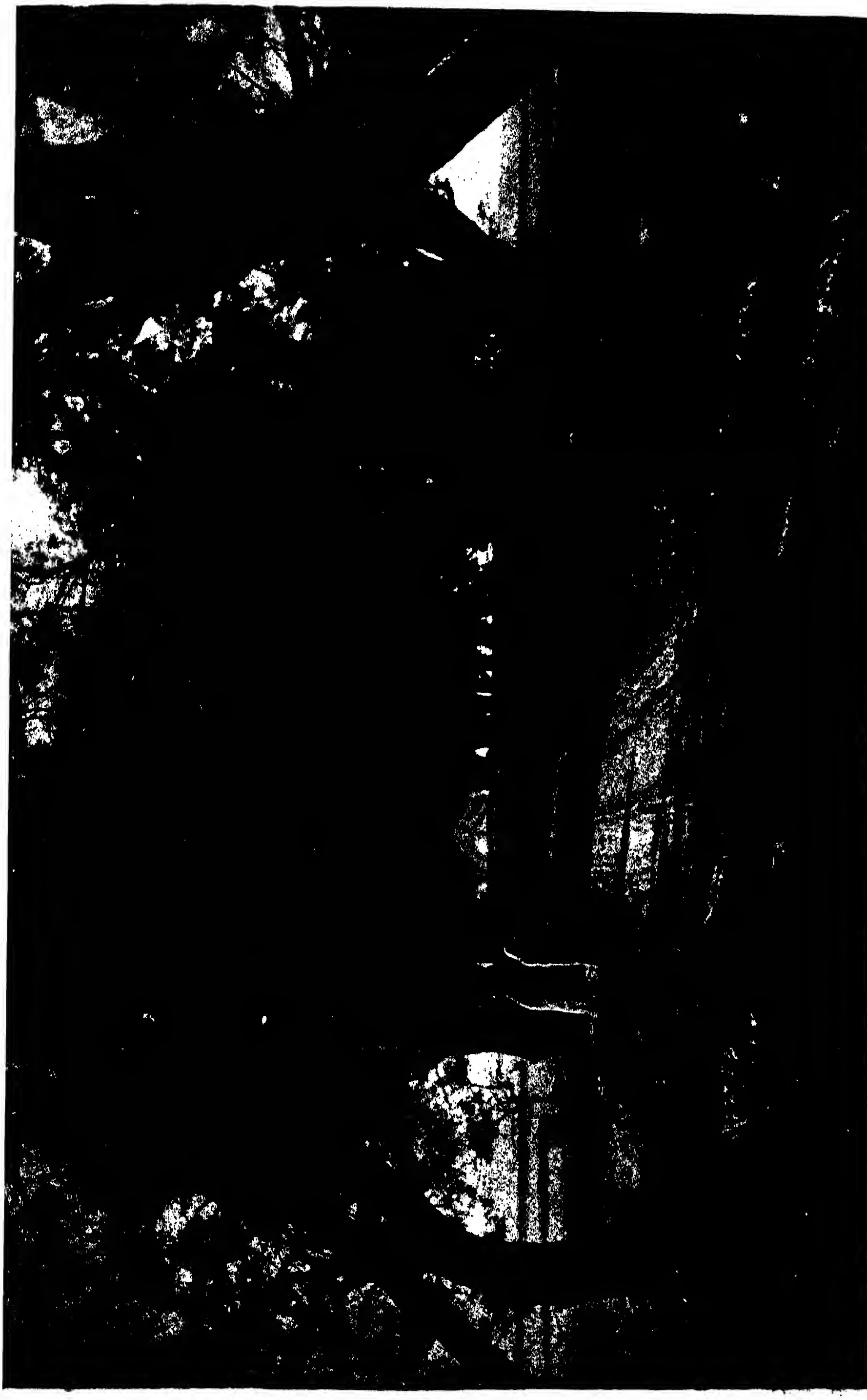
IN my early school-days, as we sang the "Scottish Blue-bell," I sometimes envied the "proud Indian," his "boast of jessamine bowers—the mountain, the valley with all their wild spell." The poet's picture of the rich East was too fascinating—it overshadowed the blue-bell. I have since learned that envy need not have hushed a note of the song. The jessamine blooms in the market garden under the "city wall," and mingles its heavy-sweet with the odour of the bazaar. But there are valleys in India that glow and swelter in ultra-tropical heat, yet which bloom fresh and fair during several months of the year. A large part of the Peshawar District comprises one of those favoured vales. Here, blessed by copious irrigation, the fields are more or less green always, and the landscape is graced by charming groups and lines of trees. It is in praise of one of these trees, the "ghaz" of the frontier, that I would write. Throughout the Punjab it is known as the "frash." Brandis calls it *Tamarix articulata*, and notes that it is found beyond India, in Afghanistan, Persia, Arabia, and even in North and Central Africa. Some among us who have enthusiastically hunted for herbarium specimens may have discovered an ally of the "frash" on the coast of England. My introduction to the family was by the lake at Kew. From Delhi to the Khyber, by the Grand Trunk Road, and over the yellow plains, or uprising columnar from the corn-fields, the "frash" is a familiar tree. (Plate XXVII.) On this wide area, when the district officer despairs of establishing the



UNDER THE "FRASH" IN JUNE.

shisham (*Dalbergia sissoo*), the mulberry, the poplar, the *ber* (*Zizyphus jujuba*), or even the *kikar* (*Acacia arabica*), he hopefully plants "frash," and the good tree rarely disappoints him, be the land wet or stony, deep and fertile, or even a salt-stricken plain. The cultivator in the Punjab and the North-West Frontier Province knows all about the "frash." He understands how to propagate it, and no tree is more easily raised, nor is stock of any more abundantly to hand. When it is desired to establish a boundary line between two villages, or to demarcate holdings, stout cuttings are planted *in situ* during the spring or when rain falls in August, in the confident knowledge that despite neglect, these will grow and ultimately win from the camel and the goat, the grasshopper, the village boy, or the ubiquitous white-ant.

On a fine spring morning the Peshawar valley is beautiful, fresh and sylvan. The coppiced "frash" and spreading mulberry embower the hamlet, sentinel trees stand out in the corn; the roads and the canals, the streams and water courses are traced in lines of dark pine-green, with here and there the brighter hue of tender new-clad mulberry and *shisham.* The humble cultivator is the artist who has made the landscape beautiful. He has silently, patiently, of his own free will planted "frash" to shelter his crops and cattle, to supply beams for his dwelling or fuel for the home, to provide money to marry his children.

The mulberry is the "Old Apple Tree" of the Pathan boy and girl, their leafy school of Nature-study; the tree in which they perched as they watched the ripening corn, or under whose cool shade they played and slumbered. But the "frash" is the household's friend—the "Codlin" *and* "Short" when crops fail or the cattle are afflicted, when ready-money is demanded. Most frequently the mulberry is self-sown. Like Topsy it "just growed" and the family gathered round it as its sheltering arms extended. Unlike the dwarf species of the lazy river-flat, the "frash" of the field is never a natural seedling in the North-West Frontier Province. Every tree has been planted as a cutting. Had it been necessary for the cultivator to sow seed and carefully raise seedlings, or procure these from a nursery, it is probable that the trees of the Peshawar

valley and a large part of the Punjab would at the present time be confined to the roadsides and canal banks. It is certain that wthout the "frash" the fuel supply of North-West India would be far more scanty than it is now. During the period of the war this copse-wood has proved a "mortgage-lifter" to many Peshawar cultivators; the woodman has been busy around the villages since 1914, providing fuel for the troops on the frontier.

By the roadside on good land there are trees which are more satisfactory than the "frash." Admirable as the tree is in the field or by the village lanes, few will disagree with the writer who not long ago stated in the *Civil and Military Gazette* that the time had come when the "frash" should go from the city and cantonment. Trees that are propagated by cuttings develop a shallow root-system, and are blown down more readily than those that are raised from seeds. The "frash" is the first tree to fall before the dust-storm. Then in these days of whirling motor cars and trains of motor lorries, the roadside "frash" becomes dust-laden and unpleasing. It is no longer suitable for the roadside, it is the cultivator's tree, it is a copse-wood. Grown old, tottering and gaunt, it is picturesque but hardly a shady roadside tree. Yet the "frash" can and should be young and fresh always, for no matter how large its limbs may be, these soon break into vigorous growth when they are pruned. Even the neglected fallen trunk by the wayside mantles in tender purple and green for several years after it is laid low.

The "frash" is also useful in some minor ways. The fruit-grower has found it an excellent wind-break for his orchard. A very promising hedge which was grown from cuttings and is less than 2½ years of age is shown in the accompanying figure. Sometimes the bark of the trees is used by the villagers in tanning, and this is another reason why the "frash" should not be planted on public highways, especially in tracts where other trees are scarce. A considerable quantity of tuberculate galls from which a dye may be prepared, is borne by the "frash," and in March and April the village girls may be seen collecting these from under the trees.

There are surely few agricultural tracts where the small farmer, unaided by the State, has made what might have been a bare country-

side one of sylvan beauty. But the cultivator of the Peshawar valley has done this, and he deserves commendation for his choice

A wind-break of "frash." It was grown from cuttings and is less than 2½ years old.

of the "frash," a copse-wood that is beautiful and useful. He has done his part in providing a continuous supply of timber that fulfils his requirements, and meets a considerable part of the local demand for fuel and light beams. In the establishment of plantations the expert sylviculturist may prefer to use rapid-growing "soft woods," but no tree that is grown from *seed* will easily displace the "frash" in the favour of the North-West Frontier Province cultivator.

other occasions unknown to me, as it is impossible to get attendants of the class the farm is able to employ to understand the danger susceptible animals run by grazing in a surra-infected area, and if they did understand it, most of them are too careless and irresponsible to take any trouble to avoid it. The risk of infection was increased by corps camels occasionally straying and getting on to farm land.

From September on, the farm camels were kept under close observation with a view to the detection of surra, but it was not till 2nd October that the disease was definitely diagnosed in any of them. On that date No. 13 was found to be affected.

All the farm camels (8 in number) were immediately sent out to a camp in the middle of a dry grazing area some miles from any other susceptible stock, the affected animal was isolated and treated. Surra was definitely diagnosed in three more of the camels as follows :—In No. 14 on October 12th, in Nos. 9 and 12 on October 23rd.

All the camels were in fair condition. No. 13 was fat. The affected animals were all treated, details of which will be found below. The other four camels have remained surra-free up to the time of writing (February 1919).

The presence of the disease in farm camels caused acute anxiety as to other susceptible farm stock.

At that time there were present in the Home Farm 29 pony and 34 donkey mares with foals at foot, with one pony filly running with them, twenty-four pony mares without foals, 9 mule and 4 donkey foals weaned on October 15th (up to October 15th had been running with other mares and foals), 100 donkey mares and fillies, 3 Arab mares, 10 to 12 mares in foaling or hospital boxes, 7 donkey and one horse stallion in boxes. There were also 3 pony mares, 2 mule foals, and a donkey colt, in an isolation line about half a mile from the Home Farm ; the mares had been in the Home Farm till the beginning of October.

There were also 182 young stock mules and donkey colts in paddocks about half a mile from the Home Farm, and 11 pony and 25 donkey mares all heavy in foal at Chowni about 2 miles away.

The majority of the above animals were unbroken young stock.

The small veterinary staff at my disposal was very fully occupied with outbreaks of rinderpest and hæmorrhagic septicæmia among farm cattle, in addition to abnormally heavy ordinary hospital case work.

I was only able to spare one man to assist me in surra-detection work.

All the animals in the Home Farm, in the isolation hospital, had temperatures taken morning and evening daily, with the exception of the 100 donkey mares and fillies which were dealt with on alternate days.

Blood from all animals with suspicious temperatures was examined on the spot.

Surra was detected in the following animals on the following dates :—

Pony mare No. 57 on October 16th (mare had a foal at foot).

Pony mare No. 73 on October 17th (had foal at foot).

Pony mare No. 98 on October 18th (this mare was in the isolation hospital. She had a foal at foot).

Donkey mare No. 88 on October 18th (had a foal at foot).

Pony mare No. 130 on October 18th (foal had been weaned on October 15th).

Donkey mare No. 6 on October 18th (had a foal at foot).

Pony mare No. 74 on October 27th (foal had been weaned on October 15th).

These mares were all in the Home Farm and had all been grazing together up till October 15th. After detection of the first case, the whole herd was kept up and stall-fed in lines where they could get into cover in the day time to escape biting flies.

During October I was unable to pay much attention to the animals in the paddocks and at Chowni, but on November 10th mare No. 49 at Chowni was found to have surra, and mare No. 124 on the 11th. These mares had been moved to Chowni from the Home Farm on September 10th.

From November 11th, 1917, up to date (February 1919) no more cases of surra have been detected on any animal in this farm.

Of the above cases, pony mare No. 57 and donkey mare No. 6 were destroyed; the remaining animals were treated.

Before proceeding to details of treatment which will be found below, the following points seem to me to be of interest.

Period of incubation. In equine surra, I believe, this is said not to exceed 10 days. The disease was detected in pony mare No. 74 on the 27th; the last previous case among animals with which she was in contact was detected on the 18th. From the 17th onwards mare No. 74 and her companions were kept up and stall-fed and had shelter from biting flies. It is probable the mare was infected before the 17th, and as she was free of trypanosomes between 17th and 27th and the period between paroxysms does not usually exceed 10 days, it is probable that the disease was diagnosed in the first paroxysms.

Probably in natural cases the period of incubation may exceed 10 days.

Susceptibility of foals. I believe there is a superstition among camel-owners in surra tracts to the effect that young camels under their mothers are immune to surra. Leese, I believe, proved that age had no effect on the susceptibility of camels to surra, but in the light of my experience in this outbreak it seems probable that young stock do naturally escape surra more frequently than their parents. Possibly their thick woolly coats may be some protection against the biting fly.

At all events in the above outbreak no foal contracted the disease, and all the pony and donkey mares affected either had foals under them at the time the disease was detected or had them weaned from them a day or so before.

Mares Nos. 98, 73 and 88 were treated and their foals accompanied them to the isolation hospital, and so remained in contact with the disease for a long period. Biting flies too were numerous up to the end of October.

Agent of transmission. In this outbreak everything points to a "tabanus" as the agent of transmission. The common biting

flies of the district are *Stomoxys*, *Lyperosia* and *Hippoboscidæ*. Tabanidæ can generally be found near water in the hot weather and rains but as a rule is not a common fly.

In 1917, during August, September and October, Tabanidæ were numerous ; *Stomoxys* and *Lyperosia* were swarming everywhere.

At the time surra was diagnosed in pony mare No. 98 she was with two other pony mares Nos. 80 and 60, her own and another foal, and one 3-year old donkey colt. No. 60 mare is a light roan. *Stomoxys* and *Lyperosia* were so numerous that the roan mare was literally black with them in the morning and evening. Drops of blood from fly punctures on the animals could be detected at any time on any of the animals. These mares and foals remained several months with the surra cases under treatment, but none of them developed surra.

(*a*) As an item of interest, in the cases of the above blood examinations, Filaria were detected in the blood of only two, both pony mares. In one of the mares the worm was only detected on one occasion, although her blood was examined daily for two months.

(*b*) I had fully expected, if the monsoon of 1918 proved heavy, to experience another outbreak of surra, or at all events to hear of the disease in the neighbourhood, as the camel corps camels were camped in close proximity to a much frequented road, and must have infected many local camels which had to pass right through the camp to get into Hissar.

As a matter of fact monsoon rains were light, nothing was heard of surra in this district in 1918, but the disease is often so chronic in camels that it is quite probable camels infected in 1917 will be alive and be a source of danger to the district in 1919.

Details of treatments.

The following are details of treatments employed.

The large doses of antimony tartrate used intravenously were tried on the recommendation of Lieut. W. A. Poole, I.C.V.D., I.A.R.O., at the time acting as Camel Specialist. I understand large doses in camels were first tried by Mr. H. E. Cross, when that officer was Camel Specialist, with very encouraging results.

Donkey Mare No. 88 was treated by the arsenic alone method, after 3 grm. of soamin had been injected subcutaneously to drive the trypanosomes from the circulation; beginning with 0·750 grm. in bolus, the mare received 20·25 grm. of arsenic in 19 days. The arsenic was given on alternate days. The last dose was 3·25 grm. The mare weighed about 450 lb. She died of arsenic poisoning on the 24th day. There had been no return of trypanosomes to the circulation.

Pony Mare No. 74, weight 697 lb., was treated as above; beginning with 4 grm. soamin subcutaneously on October 27th, she received 38 grm. of arsenic in 23 days, the last dose being 4·75 grm. This mare was for a long time regarded as cured; by December 7th her weight had increased to 770 lb.

In April 1918 she was put on to light work; her temperature was, however, still taken night and morning, and her blood was examined weekly.

On February 21st, 1918, her morning temperature was 102·6°F. On the same evening it was down to 101·2°F. At that time her blood was being examined daily, and there was no sign of trypanosomes in the circulation.

Except for that one occasion, the mare's temperature remained normal till July 10th, when her morning temperature was 102°F. and trypanosomes were found present in the circulation. The mare was given 300 c.c. of a 1 per cent. solution of antimony tartrate intravenously. The dose proved too big and she died on July 11th, 1918.

The mare had visibly lost condition during June.

Pony Mare No. 130 was treated, to commence with, as above. The arsenic in bolus was increased from 1 to 5 grm. in 20 days, but trypanosomes appeared once during treatment, and again 3 days after the treatment was stopped. The treatment was repeated and 10 doses in 20 days were given, being increased from 4 to 7 grm. of arsenic. Trypanosomes reappeared 5 days after treatment. The mare was next treated with soamin subcutaneously, antimony tartrate intravenously, and arsenic by the mouth; 0·7 grm. of antimony tartrate was the maximum dose of that drug given. The

mare remained free of trypanosomes for 22 days. She was then treated by antimony tartrate alone, and received up to 200 c.c. of 1 per cent. solution intravenously. She remained free of trypano somes for 41 days after the treatment ended. She was eventually poisoned in an attempt to find out the safe dose of antimony tartrate intravenously.

This mare was in poor condition when treatment began, but improved in condition all the time.

She was fat when she died. Her normal weight was about 800 lb ; shortly before her death she weighed 860 lb.

Pony Mare No. 49 was treated on the same lines as the above ; doses of arsenic in the first treatment were rapidly increased from 1 to 5 grm., but trypanosomes appeared twice during treatment and immediately after. After combined soamin, arsenic and antimony tartrate the mare only remained 13 days free. She was eventually destroyed. She was in poor condition when treatment commenced, and weighed 700 lb. on 10th November. She improved in condition, and on the 16th December weighed 824 lb., part of the increase in weight being due to the fact that she was in foal.

Shortly before she was destroyed she slipped her foal; she carried the foal to within one month of the normal gestation period.

Pony Mare No. 98, to begin with, was treated in the same way as above cases, and like them received very large doses of arsenic in bolus (up to 6·5 grm.). This mare, to start with, was in fair condition and tended to improve, but arsenic alone had little effect on the trypanosomes which appeared in the circulation during treatment. Combined soamin, arsenic and tartrate emetic (small doses) gave only slightly better results.

On February 9th treatment with antimony tartrate alone was begun. 250 c.c. of 1 per cent. solution was injected intravenously. The dose was repeated on February 12th, 15th, 18th, 21st and 24th.

Trypanosomes reappeared in the circulation on May 16th. On that date 180 c.c. of 1 per cent. solution of antimony tartrate was injected intravenously ; a larger dose had been proposed, but the injection was stopped owing to the mare exhibiting signs of distress.

On May 19th 400 c.c. of 1 per cent. solution was injected. Since that date the mare has had no rise of temperature, and trypanosomes have not been detected in the circulation. Her blood was examined almost daily up to October 31st, 1918, and two or three times weekly since.

A rabbit was inoculated with 10 c.c. of blood from this mare on November 22nd, and has remained healthy to date (February 1919).

The mare weighed 792 lb. on the 10th December, 1917, and 830 lb. on 1st May, 1918.

Pony Mare No. 73, to begin with, was treated in the same way as the above.

She received up to 6 grm. of arsenic in bolus. Trypanosomes reappeared in circulation, 12 days after conclusion of treatment.

Combined soamin, arsenic and antimony tartrate (small doses) gave no better results.

Combined prolonged treatment with soamin, arsenic and antimony tartrate, using larger doses of antimony tartrate, was begun on January 18th, and concluded on March 14th. As always in these cases, soamin was given subcutaneously, arsenic by the mouth, and antimony tartrate intravenously. Up to 200 c.c. of 1 per cent. solution of antimony tartrate was injected intravenously. The mare remained free of trypanosomes until May 25th.

On May 25th, 320 c.c. of 1 per cent. solution of antimony tartrate was injected intravenously. A larger dose was intended, but the mare's jugular glands were sore and she was fidgety under manipulation, and some of the solution got under the skin. A considerable swelling resulted, and the mare was off feed for several days. No further injections have been made to date. Trypanosomes present on the 25th May disappeared a few hours after the injection was made and have not reappeared. The mare's temperature also has remained normal. On November 22nd a rabbit was inoculated with 10 c.c. of blood from this mare. The rabbit has remained healthy.

The mare has maintained fair condition; on the 9th December, 1917, she weighed 768 lb. and on the 1st May, 1918, 860 lb.

Pony Mare No. 124 was heavy in foal when treatment began on November 11th. She remained free of trypanosomes for 20 days

after arsenic alone treatment. The maximum dose of arsenic was 5·5 grm.

The mare weighed 684 lb. on November 11th and 760 lb. on December 9th.

Combined soamin, arsenic, and antimony tartrate was begun on January 21st and continued till February 15th. The mare gave birth to a healthy full-time foal on March 18th. During March, before the mare foaled, several doses of soamin (subcutaneously) were given. The mare had plenty of milk and the foal did well, but trypanosomes reappeared in the mare's blood on April 29th.

On that date an injection of 300 c.c. of 1 per cent. solution antimony tartrate was made intravenously.

She remained free of trypanosomes till September 29th, 1918. On that date she was given 4 grm. soamin subcutaneously.

Trypanosomes disappeared and did not reappear till November 11th; 4 grm. soamin was again injected. Trypanosomes reappeared on November 21st.

5 grm. soamin was given subcutaneously. Trypanosomes have not reappeared up to date (February 1919).

The foal, now 10 months old, has done exceptionally well since birth, and is now about the finest male foal of his age on this farm.

Camel No. 9. Trypanosomes were first found in the circulation on October 24th, 1917. He was treated by combined soamin subcutaneously and arsenic intravenously, as recommended by the Camel Specialist's extant reports. The treatment concluded on Nov. 11th with 1·5 grm. arsenic intravenously and the camel off his feed. The camel fed again on the 12th, and has not been sick or sorry since up to date (February 1919). On December 10th, 1917, he weighed 1,208 lb.

His blood and temperature were examined twice weekly till December 1918, and trypanosomes have never been detected in the circulation since October 24th, 1917.

A rabbit inoculated with 10 c.c. of blood from this camel on November 27th, 1918, has remained healthy.

Camel No. 12. Trypanosomes were detected in the circulation on October 23rd, 1917. He was treated in the same way as camel

No. 9, and like camel No. 9, 15 grm. of arsenic intravenously, his last dose, put him off his feed for one day.

He has never been sick or sorry since. He was kept under observation up to December 1918. 10 c.c. of his blood was inoculated into a rabbit on November 22nd. The rabbit remains healthy.

Camel No. 14. Trypanosomes were detected in his blood on October 12th, 1917. He was treated in the same way as above and has remained healthy up to date. The rabbit inoculated with his blood on November 22nd, 1918, also remains healthy.

Camel No. 13. A Dachi. Trypanosomes were first detected on October 2nd, 1917. The arsenic and soamin treatment was not successful. Trypanosomes reappeared in the camel blood on December 9th, 45 days after the first treatment concluded.

The treatment was repeated, using small doses of antimony tartrate intravenously alternated with the arsenic doses.

Trypanosomes again reappeared 45 days after treatment concluded.

On February 14th, 1918, the camel received intravenously 250 c.c. of 1 per cent. solution of antimony tartrate. This dose was repeated on the following dates:—February 16th, 18th, 21st, 26th, March 4th, 8th, 13th and 17th.

Since February 14th, 1918, no trypanosomes have ever been detected in the blood of this camel. A rabbit inoculated on November 22nd remained healthy. The camel was kept under observation up to February 1919 and will remain under observation as opportunity permits.

All the above camels were put into regular work immediately after treatment concluded, and on some occasions worked while under treatment.

All are now in very good condition.

The Dachi No. 13 was always from the first in fat condition. She weighed 1,422 lb. on the 10th December, 1917.

All the above cases, except for one month when he was on leave, have been in the charge of Veterinary Assistant Ata Mohammed (now 2nd Farm Overseer on this farm); while he was

away they were in my sole charge. Nearly all the doses to equines were given in my presence or by me. The camels were treated (except for the one month) entirely by Veterinary Assistant Ata Mohammed, whose previous experience of the disease while serving under the Camel Specialist came in very useful.

The above results appear to me to be decidedly encouraging, while in the light of our present knowledge of surra I hesitate to claim definite cures, hasty condemnation of treatment should, I think, be deprecated.

THE IMPROVEMENT OF INDIAN DAIRY CATTLE.*

BY

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THE improvement of the milch cattle of India has occupied considerable attention in recent years, both at the hands of the departments of agriculture and of the public. It is noteworthy that, in fact, all questions connected with dairying are receiving an increasing amount of attention and study, so much so that dairy husbandry and the problems connected therewith, promise to become one of the foremost among the various branches of agricultural study in this country. We have already a fair number of large and well-equipped dairies conducted mostly by the Military Department, where milk is handled in large quantities, cream and butter made by up-to-date methods, and even the manufacture of cheese taken up. There is a goodly amount of business done by importers of dairy machinery, chiefly of cream separators and butter churns. We have a Dairy Farmers' Association in the country conducting a journal devoted to dairying matters, and an examination for the National Diploma in Dairying has been instituted which bids fair to become a coveted honour among our agricultural graduates. There is also a growing amount of recognition by Government, for some of the provincial departments of agriculture are being strengthened by the appointment of specialists in animal husbandry. Recently, too, His Excellency Lord Willingdon gave a strong impetus to the industry by himself setting an example to the landed

* A paper read at the Sixth Indian Science Congress, Bombay, January 1919

aristocracy of India, in the matter not only of keeping high grade dairy herds on their home farms but also of building up such a herd by steady improvement.

The industry indeed is in such a backward condition and the need for improvement so great and urgent that we require all this and a great deal more of public attention bestowed on this subject. The problem of milk supply in cities is becoming every day more acute, while even in parts of the country noted for their dairy products, milk, butter and *ghee* are becoming scarce and high priced, and such as is available is often foully and shamefully adulterated. More milk and wholesome milk has to be produced at prices not so high as to make it beyond the reach of all but the well-to-do classes of people. The prices of dairy cattle and of feeds and fodders have gone up, and it seems to be admitted on all hands that the city dairyman is by no means a prosperous individual—oftentimes hopelessly in debt, and at best only making a hand-to-mouth existence.

The problem has been studied by many people, and various recommendations such as may be suited to different local conditions made. The most important among such recommendations are, firstly, the production of milk not in the cities themselves but on special farms, or as part of general farming, out in the country and the transport of the milk to the city for sale, a measure much the same as one finds in European and American cities and requiring quick transport, the organization of wholesale depôts, refrigerating arrangements, and so on. This indeed is bound to come, for it is, I venture to think, one of these changes which are brought about automatically by the growth of cities of the modern type. The second recommendation is the improvement of the milking quality of the animals themselves, *i.e.*, the breeding of a superior type of milk animal. The importance of this recommendation is too obvious to be emphasized, for the average Indian cow or buffalo seldom yields milk enough to pay for its keep.

A surer means of lifting the industry out of its present unsatisfactory condition than this one of breeding a superior type of animal cannot be thought of. When, however, we come to decide as to the method by which we have to attain this end, we are faced with

several difficulties. Shall we confine ourselves in this matter to the indigenous Indian breeds selecting the best among them, and continue the process of selection and weeding out until we get together a type considerably superior to the general bulk? There is no doubt much to be said for this method. Speaking of our own Mysore cattle, it is not uncommon to find cows yielding nearly 4,000 lb. of milk in a lactation period, and if this is a measure of the improvement possible in a general herd, it will be no small achievement if we can breed by selection alone such a type. There is again the further advantage of suitability of the breeds to their tract, for they are native to it; and, furthermore, there is the certainty of a handsome price for male calves, for these grow into a much-prized type of draft bulls. The method is however very slow, as it will take several generations of cattle to raise the level of even a picked herd. Shall we then adopt the method of crossing the local cows with English or Australian sires of reputed milking breeds? The production of animals with considerably increased milking capacity by this method is exceedingly quick, for the very first generation of the cross-bred cows shows the improvement very strikingly indeed. It is this somewhat tempting prospect of being able to collect together within a period of, say, some three to five years a herd with the high milking quality we desire so much that constitutes the merit of this method. One has only to keep a good British or Australian sire—as a matter of fact the Ayrshire seems to be the one much thought of for this country—in a herd of local cows, and wait the short period of three to five years when the offspring born of these two breeds grow and become milkers themselves.

The improvement in the milking quality of the offspring over that of their pure bred country mothers is really remarkable, as may be within the experience of all who may have compared the milk yields of such animals, so much so that it would seem indeed that the cross-bred cows would solve the problem of the milk supply in cities, at any rate, as far as the production of milk is concerned. Shall we take it then that those of us who have charge of breeding stations for dairy cattle should concentrate our efforts in this particular line of breeding in preference to grading up indigenous cattle

by selection through several years? This I need hardly point out is a most important matter to decide, for it involves the breaking of the type of Indian cattle and the introduction into the country of a mixture of types, a measure which can certainly not be decided upon except with the fullest knowledge of the consequences. I make this the justification for my venturing to make a few observations in regard to the limitations and difficulties of this method of breeding. I do not refer to the comparatively greater susceptibility of these cross-bred cattle to the cattle epidemics of India, though that itself is a serious matter; for it may be expected that in the cross-bred herds kept by professional dairy farmers, the necessary precautions against these epidemics, such as inoculation, segregation and so on, will be attended to promptly.

I should like to invite your attention to a different aspect of the subject, *viz.*, the risk of disappointment if certain precautions are not taken, and the production of what I may call cross-bred scrub cattle which partake of the good qualities of neither breed and perhaps combine the bad qualities of both. It is a striking fact that the cross-bred offspring of the first generation invariably possess the good milking qualities of the breed to which the foreign sire belongs. Does this justify us in inferring that the milking quality behaves as a "dominant" in the Mendelian sense? I am aware that when we come to a character like the milking quality, which is the resultant of a number of factors in the constitution of an animal, and try to apply the principles of Mendelism to the manner of its transmission, we are treading upon thin ice. But these principles have been applied in the plant kingdom to several qualities of economic value, themselves the resultant of many factors, and I do not know if in regard to cattle, others have not sought to apply these principles to this very characteristic, *viz.*, the milking quality. If we are justified in considering this quality as a Mendelian "dominant," certain interesting conclusions follow which can guide us as to how best we can take advantage of the method on the one hand, and how we can avoid disappointment on the other.

Thus it ought to follow that (1) if we mate the pure-bred sire and one of the first generation cross-bred cows, all the offspring will

possess the dominant characteristic and will therefore be good milkers; (2) if however we mate the first generation cross-bred cow with first generation cross-bred bull, we ought to get in the progeny good milkers and bad in the proportion of 3 to 1, *i.e.*, 25 per cent. of the total must be, so far as the milking quality is considered, just as poor as the original country cow from which we started. All of them cannot be equally good by virtue of their being equal as regards the blood of the original foreign parent contained by them, but this 25 per cent. will be inferior to the remainder; (3) if again we mate a bull of the first generation cross with a country cow, that is to say, if instead of using a pure-bred foreign sire we use a first generation cross-bred bull as sire, in the herd we ought to get in the offspring good and bad milkers in the proportion of 1 to 1, that is, 50 per cent. of the total consist of poor milkers. So the proportion in this case is still further reduced. That is to say, although on account of the fact that the progeny in each case is alike as regards the degree of foreign blood in them, and breeders would say that they should consequently possess the milking or other quality in an equal measure, yet if our theory is correct, a large number cannot possess that quality. On these considerations it follows that except where we use a pure-bred foreign sire, whether it be on the pure local cow or on the first generation cross, in all other cases it will be somewhat of a toss-up as to what kind of animal we shall be getting, for, as stated above, we get both good and bad milkers. It is to this uncertainty or diminished chance of producing good animals, except where the above-mentioned precaution of using only a pure-bred sire is adopted, that I wish to invite your attention. I have come across many instances where cows evidently with foreign blood in them, as may be inferred from the suppressed hump and the broken coat colour, have proved no better than the local cows in their milking quality. Disappointments like this will increase if, as it once came under my notice, professional keepers of breeding bulls in and about the city try to meet the demand for a foreign sire by keeping only a half-bred bull instead of a pure bred, because a half-bred bull is the only one they can afford to buy.

There is then again the question of the bull-calves of this mixed progeny. In the case of pure bred local cattle, so far as Mysore is concerned, one of the chief sources of ready money to the farmer is his male calves, and with the city dairymen of Bangalore and Mysore the hope of obtaining a bull-calf from the cows is the only inducement to keep a cow which, so far as her milk yield is concerned, may be too poor to pay for her feed. The more nearly the bull-calf conforms to the popular taste in the matter of colour, physical configuration and other characters, the higher the price it fetches. This is only as I said in the case of the pure local breeds of cattle. In regard to bull-calves of cross-bred cattle, just at present at least, no buyer of draft cattle would as much as look at them. If they do find a sale, they fetch only the price of scrub cattle. The absence of the hump and the somewhat strange build of the frame and the broken colour and other features do not attract buyers. Popular belief *may be* wrong. These heavy and long bodied cross-bred bulls may be powerful animals, hardy as the local ones, and suited to the needs of the ryot. In fact a few cross-bred bullocks may be occasionally seen even in the countryside ; while in cities, such bullock teams are frequently seen hauling heavy loads. It is, however, reasonable to expect that these beasts cannot be as hardy as the local breeds of bullocks, nor so capable of withstanding cattle diseases either, and in the hands of the ryot out in the villages the matter of inoculation against diseases or segregation cannot be thought of. It is, however, different with the cross-bred cows, for they are likely to be located in special dairy farms and looked after properly. It is this question then of the disposal of bull-calves, in a country where the slaughter of cattle except those which are unfit to live is considered a horrible sin, that has cooled the enthusiasm of many a dairy expert keen on the subject of cross-breeding.

Lastly is the fate of the scrub progeny of the cross-bred ; we have seen that except in the cases where only the pure-bred sire is used, the offspring of cross-bred cattle cannot be all good milkers. The more we use other than pure-bred sires, the more are these uncertain cattle thrown out, both bulls and cows, the bulls possessing none of the characteristics prized by buyers of draft cattle and the

cows useless as milkers, and both being equally at a disadvantage as against pure country cattle in their susceptibility to cattle diseases. The only method of restricting the chances of such undesirable cattle is to arrange that cross-bred bull-calves are castrated at the breeding farms before the age when they can be of use as sires, just as we have been recommending for years past in the case of the undesirable male calves of the village cattle themselves.

The popularity of the cross-bred cow as a dairy animal is unquestioned and is steadily increasing. In a census I took some years ago of the dairy cattle of Bangalore this was strikingly brought out. The only reason limiting their more extended use is the loss they imply in their begetting bull-calves of practically no value. The fact that lately some among even the cross-bred cows have proved disappointing as milkers is further operating against their popularity, and I believe it is due to the indiscriminate use of cross-bred sires instead of the pure-bred ones. The fact that in their outward appearance these cross-bred bulls resemble closely their pure-bred parent, while their potency for mischief is not so apparent, is the cause of this mistake.

Probably we shall have to look to the cross-bred cow in this country more and more for the solution of the problem of the milk supply to cities, and I venture to think that the precaution of using a pure-bred bull either to meet the need of city cow-keepers or for the use of special dairy farms in the country, will minimize the risks and disappointments attendant upon the resort to this method of breeding cows for the milk trade of the country.

NOTE ON LAND DRAINAGE IN IRRIGATED TRACTS OF THE BOMBAY DECCAN.*

BY

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JUST as the conditions which determine irrigation practice in the Bombay Deccan differ in almost every essential from those which determine irrigation practice in Northern India, so the problem which confronts us with reference to land drainage differs in almost every essential.

Just as an irrigation engineer when he comes to the Deccan has to unlearn or forget a lot he hitherto looked on as the A B C of irrigation practice, so the officer in charge of drainage and reclamation can make little headway until he realizes that the problem to be faced is essentially different from what has been usually met with elsewhere.

In Northern India, I understand that—

(1) the salt pre-existed the canals;
(2) sodium carbonate gives most trouble;
(3) the soil is homogeneous; and
(4) the groundfall small.

In the Deccan—

(1) the damage may be said to be entirely due to the opening of canals;
(2) sodium carbonate is almost entirely absent, sodium sulphate and, to a less extent, chloride being in great excess;

* A paper read at the Sixth Indian Science Congress, Bombay, January 1919.

(3) the soils, subsoils and substrata vary excessively and abruptly; and

(4) the groundfall is very great (of the order of 1 in 150).

In the Deccan we are mainly concerned with six quite distinct types of surface soils and six distinct types of substrata, and these vary enormously in thickness, the change frequently being very abrupt.

From what I have said two points will be clear—

(1) that the conditions are excessively complicated; and

(2) that the problem is mainly one of preventive drainage

I do not propose to go into detail as to the difficulties met with and overcome, or the successive steps which led us to the conclusions arrived at, but will merely state broad facts.

As to whether some of the substrata are of colluvial or residual origin is still uncertain; but fortunately we can ignore this point for the moment.

Each drainage (*see* Cross Section) may be looked on as a valley once denuded of soil—and very much like any existing Deccan valley near the hills—which has been filled up with colluvial silt. There are five distinct types of strata :—

(1) Soil—impermeable when wet, but which cracks when dry.

(2) Subsoil (upper)—(i) impermeable.

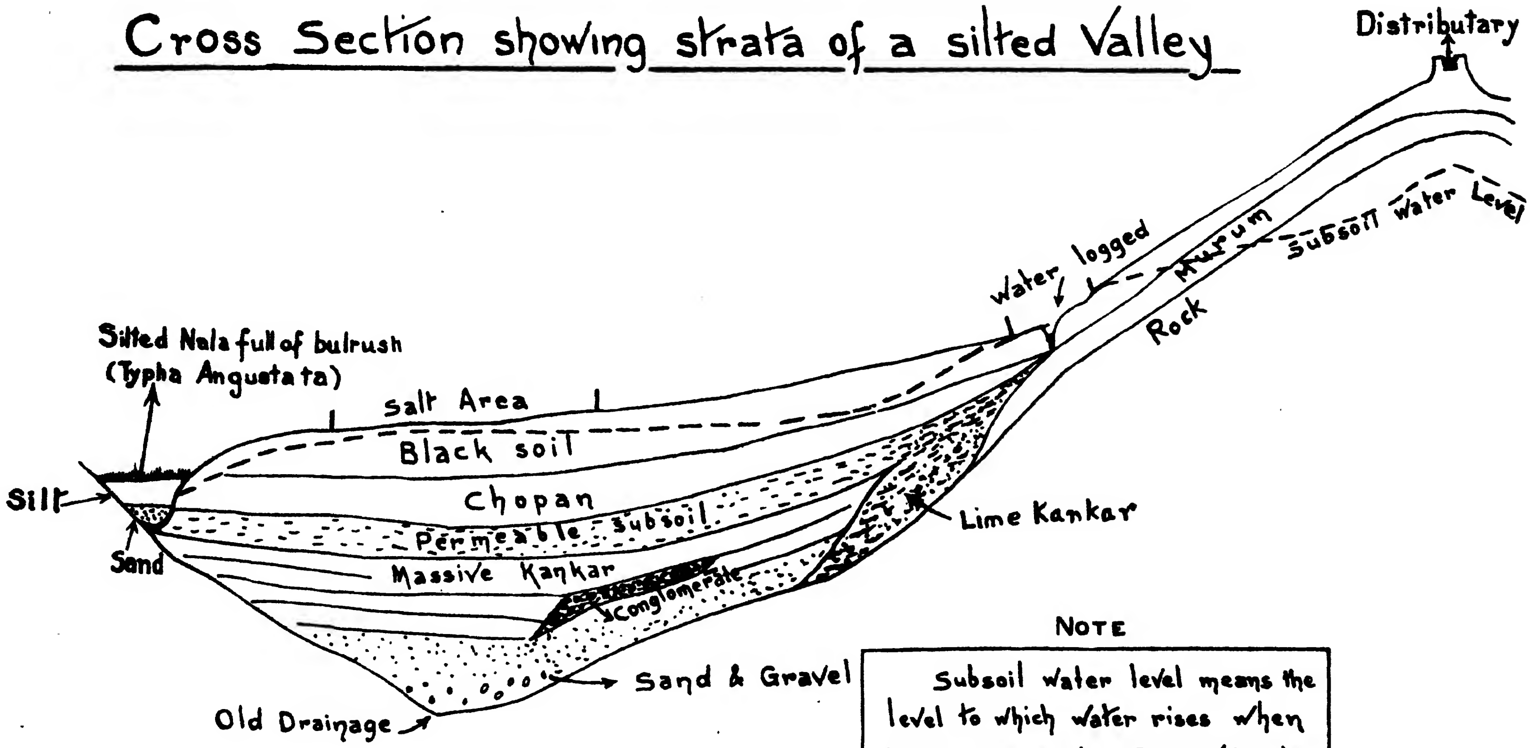
(3) Subsoil (lower)—(ii) moderately permeable.

(4) Substratum—very permeable and sometimes fissured.

(5) Fissured rock—slightly to very permeable.

Near the ridges there is a very thin layer of red soil overlying disintegrating trap rock—locally called *murum* from which it is derived. This *murum* stratum may be of considerable depth near the ridges and is excessively permeable. As we go down the sides of the ridges, we find that the surface soil gets gradually deeper both in colour and thickness, and when the *murum* becomes about 4 feet below the surface, a subsoil of yellowish red colour, locally called *chopan*, intervenes. At or near this point the permeable *murum* stratum usually dips sharply, with a consequent increase in the depth of the subsoil stratum. When this occurs we usually find

Cross Section showing strata of a silted Valley



NOTE

Subsoil water level means the level to which water rises when bores are sunk. Free water is usually not met with till the "permeable subsoil" stratum is reached.

that the subsoil is divided into an upper impermeable layer, and a lower slightly to moderately permeable layer, and the hard permeable top substratum changes to lime *kankar*, which towards the bottom of the valley changes to massive *kankar*, locally called *mân*.

We see then that we have three distinct layers of permeability, an almost impermeable upper layer of soil and subsoil, a slightly to moderately permeable subsoil, and a very permeable hard substratum, the latter very often being fissured. Bearing in mind the steep fall, it will be realized that with such strata large quantities of water will pass, through the highly permeable layer and under the impermeable surface layer, into the valleys, and will pass through into any deep river or *nala* which cuts the permeable layer. On the other hand, if the permeable layer is not cut, or if it is of insufficient thickness to get rid of the accumulated water, artesian conditions will arise, the water being imprisoned under the impermeable surface layer.

This is exactly what we find in practice in our salt areas ; and the salt is due to evaporation making a balance between water entering the subsoil, and the quantity that the natural drainage can get rid of. The amount that cannot drain away is in fact forced through the comparatively impermeable top layer until evaporation balances the excess.

As a rule, when we bore a hole in a salt area we do not find subsoil water near the surface. This is most marked. If, however, a pit is left for a couple of days, it will be found to contain water which has oozed in from the sides and bottom. This is because, as a general rule, we do not pierce the moderately permeable lower subsoil stratum till a depth of 5 to 10 feet is reached. At this level there is a sudden change, so that when the lower stratum is reached, water rushes in through the bottom of the bore hole with a hissing noise, and rises rapidly to near the surface, sometimes even pouring out at the surface. This level we call the level of " first strong flow."

When we first started this work one of our difficulties was to ascertain the permeability of soils and subsoils. Laboratory

experiments were obviously unreliable even for soils, and were quite useless for substrata. It was not until Mr. Thiselton-Dyer put me on to the 'post hole auger' which made it possible to bore holes rapidly into the subsoil, that the idea of measuring permeability by the rate of recuperation of subsoil water entered my mind. It is obviously the most perfect and simplest method to adopt, for the permeability of the stratum is measured *in situ*.

The coefficient of recuperation is measured by the formula :—

$$\frac{K}{A} = \frac{1}{T} \log \frac{H}{h}$$

where K = Coefficient.

T = Time in hours.

H = Full head of depression.

h = Head of depression after T hours.

A = Area of bore hole (which goes out in our case as it is constant).

Having obtained the level of first strong flow, and the permeability of each pit by a recuperation test, it might be thought we had only to place our drains along a line of high coefficients and at first strong flow level to effect full drainage. Unfortunately this is not the case as is exemplified in one part of the Baramati experimental area. There, a drain placed along a line of high coefficients and at first strong flow level, has had a most disappointing effect, water standing 4 feet higher than the drain at a distance of only 20 feet. Our drain has in fact merely drained off the local water, and has had practically no effect on the deep subsoil pressure which appears to be mainly developed along fissures.

This is a very extreme case, in what was the worst affected area on the whole Nira Left Bank Canal ; but many of the worst areas are modifications of this extreme type. In this area we have struck one fissure which gives a discharge of $\frac{1}{4}$ cusec, which is more than the discharge of all the drains, which total nearly a mile in length, put together.

In many cases, however, high coefficients are an excellent guide and almost always give valuable information, but they have not provided a full simple solution for all cases. In other words, it is not

always sufficient merely to trace local permeable strata ; we must also trace the natural deep subsoil flow before we can hope to make drainage fully effective at a minimum cost.

The fact that we have to deal with a pressure is what has to be grasped, and is what makes the problem so very difficult.

You cannot skim off the top water—so to speak—for the pressure still remains, transmitted through the permeable layer at a great depth and very probably through local fissures. For this reason intercepting drains have been a complete failure, the subsoil water level and pressure rising abruptly immediately below the drain. This is because we have only cut through a moderately permeable upper layer, in which the pressure is merely diffused. It is, in fact, on a parallel with trying to reduce the pressure in a water main by opening a tap in a house. Unless you can strike the main, or at least submain, you cannot appreciably affect the pressure. Another alternative would be to open hundreds of taps, *i.e.*, to open numerous small drains, but in land drainage this would be excessively costly and cannot compare with finding the main natural drainage, if that be possible.

Our first work, therefore, consists in opening out the natural deep drainages, or the original *nalas* of the denuded valley.

Recommendations have been made from time to time to reopen the existing *nalas* which have silted since the canal was opened, and where the original *nalas* and depressions were along the natural drainage lines this is what must be done. What we have found, however, is that the *nalas* very frequently do not follow the natural drainages, and that the depressions or subsidiary *nalas* seldom do. They are, in fact, nothing more than secondary superficial drainages. Besides, where they do follow the natural drainage little damage has occurred. Where the damage occurs is where the natural drainage line has been filled up with silt, and a new surface drain bearing no relation to the natural drainage has been superficially scoured.

In the canal area, many of these drainages have been opened by the irrigators along the line at which *murum* dips below the impermeable subsoil layer (*i.e.*, at the point at which the subsoil water finds an easy outlet before becoming imprisoned under the

deep *chopan* layer), while many of the partly silted natural drainages have been completely blocked by banks and levelling. Where this has been done the land is rapidly ruined, and the energy and money expended worse than wasted.

In other places the superficial trenches so far from acting as drains merely collect water, and at lower levels they act as supply channels adding to the damage instead of reducing it.

The main work to be done, therefore, is to trace the deep natural drainages, and open them out where possible. Where on account of the permeable layer being at a very great depth, as is frequently the case in the Godavari valley, all perennial irrigation must be stopped and the canal lined.

Subsidiary drainage will be comparatively simple, though costly, and this again will have to follow the natural subsidiary drainages.

Where the permeable layer is at such a depth that a drain reaching down to it is out of the question, much can still be done by driving down bore holes into this stratum, when the water rises under pressure and can be carried away by a comparatively shallow pipe drain at about 6 feet. The main difficulty about this is that the greater the depth, the greater the cost of tracing the natural drainage.

Where free drainage is prevented, and water rises to within 3 to 4 feet of the surface, damage is likely to occur. The seriousness of conditions will, therefore, be realized when it is stated that at least two-thirds of the area suitable for sugarcane in the Nira Left Bank Canal perennial section has water within this dangerous limit, and in many cases salt is merely kept down by constant heavy irrigation.

THE PREVENTION OF SOIL EROSION ON TEA ESTATES IN SOUTHERN INDIA.*

BY

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At the meeting of the Board of Agriculture in India held at Pusa in 1916, the subject of soil erosion was discussed, and it was resolved to bring to the notice of planters the fact that the serious losses due to soil erosion in the planting districts, which have taken place in the past, are to a large extent preventible.[1]

Dr. Hope, of the Indian Tea Association, has published an interesting account of the methods adopted in Java, by means of terraces, to prevent loss of valuable top soil in the tea districts.[2] Here, however, the terracing is done on new land when it is opened and before the tea is planted. The problem presented on many estates in South India is how to stop soil erosion in old established tea, and a good deal of work has been done in several districts during the last few years with the object of solving this problem in a practical and economic manner.

Two methods have been adopted with success. The first is a modification of the terracing work done in Java. At the time of pruning, trenches are opened along the contours of the slopes at intervals of four or five rows of tea bushes. These trenches are put in with a road tracer and made 18 inches to 2 feet deep, and in

* A paper read at the Sixth Indian Science Congress, Bombay, January 1919.

[1] *Proceedings of the Board of Agriculture in India held at Pusa on 7th Feb. 1916, and following days*, p. 34.

[2] Loc. cit., p. 75.

them the tea prunings are buried, the upper layer of prunings being packed so that the butts project from the ground level when the trench is filled up some 6 or 8 inches. The soil in the intervening rows of tea is then forked and manured, if necessary, and in some cases a green dressing crop is sown on it. The fence of buried prunings serves to catch any soil which is washed down from above and retain it. Unfortunately the tea has in nearly all cases been planted in such a way that the lines run up and down the hill, and not along the contours, but it is possible to arrange for the estate work, plucking and weeding, to be done along the contours, and this gradually helps to form natural terraces where the prunings have been buried. At the next pruning season, some three or four years later in our case, the terraces are repaired and improved, and new ones made in the same way. This method has been found to stop soil erosion to a very marked extent, and it is coming much into favour on moderately steep slopes.

The second method used is to abandon forking and clean weeding on very steep slopes, and to keep the soil covered all the time by some selected weed. This method of dealing with steep slopes has of course met with a great deal of opposition from the clean weeding school; but in Southern India at any rate, I am happy to say, the fetish of clean weeding is rapidly becoming obsolete. The choice of evils lying between keeping a cover of weeds on steep slopes and allowing them to be washed by the heavy monsoon rains is largely in favour of the weeds. The utmost harm that the weeds can do is to absorb moisture in the dry weather from which the tea suffers a little, but this cannot compare with the harm done by the constant loss of valuable top soil, which goes on from slopes kept clean and forked. Any plant food which the weeds take up from the soil is ultimately returned to it again as the weeds rot down, and returned in an available form, while if the weeds are leguminous there is a steady accumulation of nitrogen.

It is sometimes thought that forking prevents soil erosion, but this is far from being the case. In the process a considerable quantity of soil rolls down the slopes on to the roads, however carefully the work may be done, and much of this is carried away by

the first heavy rains. Experiments carried out in Ceylon showed that the erosion from a forked surface was more than from a similar surface kept clean-weeded. The loss of soil from a clean-weeded surface during a certain time was 814 lb., while that from a similar surface in the same time which had received a plain deep forking was 1,393 lb.

The method adopted is to establish some particular weed by means of selective weeding—that is to say, the weeding coolies are taught to leave the particular weed chosen and remove all others by hand. In this way a cover of a particular plant is soon established on the steep slopes, and this is kept *in situ* all the time: the utmost that is done to it is to sickle it and clean it out from round the bases of the tea bushes. In this way soil erosion has been almost entirely prevented even on the steepest of banks, and in the heavy rains the run-off is clear instead of being laden with silt. Moreover, the weeds accumulate humus and add by their decomposition a valuable surface layer to the soil which is retained.

A number of weeds are being used for the purpose. The ideal plant is a leguminous one, which will accumulate nitrogen, a plant which does not either climb into the tea bushes, or make too thick a mat on the ground, and one which grows only a few inches high. Such a plant is hard to find, and the one which most nearly matches the ideal is *Cassia mimosoides*, L. This plant, at elevations of 4,000 feet and over, has a short habit of growth, branching and spreading out at the base. Its feathery semi-sensitive foliage allows the rain and sun to reach the soil, while at the same time protecting it from erosion. It is fairly easily established and it seeds freely. On many estates it forms a thick cover and has been found a most useful green dressing and soil preserver.

Another leguminous weed of which use has been made is *Parochetus communis*, Hamil., a plant with a clover-like habit, but it is not easy to establish over big areas and its life is not long; it dies down to the creeping rhizome in the hot weather

When a suitable leguminous plant cannot be found or easily established, advantage is taken of the presence of other weeds, and these are encouraged and established. Among these may be

mentioned *Oxalis corniculata*, L., which is very easily established and which forms a dense short cover easily controlled. Many hundreds of acres of steep land are now under this weed, and the tea has decidedly benefited and the soil erosion under *Oxalis* is practically nil. No harm whatever has been done to the tea; yields have been maintained and in fact have increased, and in the hot weather the effect on the tea is very slight.

Any weed has been considered better than none at all on steep slopes, and when the above-mentioned cannot be established, use has been made of the following plants, either by themselves or mixed: *Cotula australis*, Hork.; *Cardamine hirsuta*, L.; *Galinsoga parviflora*, Cav.; and *Laurenberghia hirsuta*, W. & A.

The intelligent use of weeds has gone far to overcome a form of soil erosion which has in the past caused a great loss of soil and done a lot of damage in some parts of the tea districts of Travancore. Here the land is very steep and the soil is of such a loose texture that in the dry weather the angle of repose may be exceeded, and at the least touch the top soil comes sliding down. Wind even sets it moving and the plucking coolies passing through the fields send the soil tumbling down the slopes on to the roads. The loss of surface soil in such places has been enormous and very rapid, and the ridges are in some places almost entirely denuded of surface soil.

On such soils the maintenance of a permanent crop of selected weeds has gone far to stop this loss and solve the soil erosion problem, which has always been recognized by the planters as a serious and important one.

Crop of sugarcane planted with single eye-bud (point upwards).

(Group of the members of the District Agricultural Association, Dharwar, with its President Mr. E. G. Turner, I. C. S., standing in the middle.)

FURTHER EXPERIMENTS AND IMPROVEMENTS IN THE METHOD OF PLANTING SUGAR-CANE AND FURTHER STUDY OF THE POSITION OF SEED IN THE GROUND WHILE PLANTING.*

BY

M. L. KULKARNI,

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As promised in the concluding portion of my preliminary paper,[1] read at the last meeting of this Congress held at Lahore, on the single eye-bud method of planting sugarcane with the eye-bud placed upwards, I give to-day the results of outturn as obtained by that method, and compare them with other improved methods. As stated in last year's paper, the comparative experiments were tried on the Dharwar Farm which is not quite a typical place for sugarcane. Here, owing to the peculiar conditions of soil and water, the Brix reading of the cane never went above 14 per cent. in the different methods of cultivation. Hence, in comparing the outturns, only the weight of cane is taken and not the *gur* (crude sugar).

* A paper read at the Sixth Indian Science Congress, Bombay, January 1919.

[1] *The Agricultural Journal of India*, Special Indian Science Congress Number, 1918, p. 125.

The following is the statement of outturn of sugarcane under the two methods of planting :—

Number	Method of planting	Area in *gunthas* *	Number of eyes planted	Number of plants germinated after 20 days of planting	Percentage of germination	Number of plants finally kept, including mother and tiller plants	Number of canes harvested	Weight of cane harvested	REMARKS
								lb.	
1	Single eye-bud, point upwards.	1	901	833	82	1,079	843	4,325	
2	Three eye-buds, points sideways.	1	1,002	511	50	889	782	3,366	

* One *guntha* = $\frac{1}{40}$th of an acre.

Number	Method of planting	Number of eyes planted	Number of plants germinated	Percentage of germination	Number of plants finally kept, including mother and tiller plants	Number of canes harvested	Weight of canes harvested	Average weight of cane	REMARKS
							lb.	lb.	
1	Single eye-bud, point upwards.	27,030	24,990	82	32,370	25,290	129,750	5·1	57·8 tons.
2	Three eye-buds, points sideways.	30,060	15,330	50	26,670	23,460	100,980	4·3	

The Brix reading in both the methods, as said above, was only 14·2. With this reading, the outturn of *gur* obtained was in—

	lb.
(1) Single eye-bud, point upwards	12,570
(2) Three eye-buds, points sideways	9,660

Had the Brix been 18 or 19 per cent., as in the typical sugarcane tracts, the yield of *gur* would have been—

	lb.
(1) Single eye-bud, point upwards	16,2[illegible]
(2) Three eye-buds, points sideways	12,725

PLATE XXIX.


Setts with two eyes up. Setts with three eyes side. Setts with single eye up.

Sugarcane rows during the first month.


Setts with two eyes up. Setts with three eyes side. Setts with single eye up.

Sugarcane rows after a dose of ammonium sulphate was given as a top-dressing.

Side view, in its early stage, of crop of sugarcane planted with two eyes up.
(Uniformity of crop to be marked.)

From the above statement it will be seen that, in the case of single-eye-bud planting with the point upwards, the yield of canes has been about 25 per cent. more. This higher outturn is partly due to the position of eyes while planting the setts, and partly to the removal of tillers as previously described.

Plate XXVIII is a view of last year's cane crop with single eye-bud (point upwards) at the time of harvest.

Further experiments on a larger scale are being carried out on the Canal Farm at Gokak.

There are, however, certain disadvantages in the method described above. The sett being too small and exposed on both sides close to the bud, the plants developed from these buds, though quicker in germination than the side-bud planting, look somewhat unhealthy during the first month till a small dose of ammonium sulphate is given as a top-dressing, as will be seen in Plate XXIX, fig. 1. When the top-dressing is given, the crop, though weak before, begins to grow as luxuriantly as crops under other methods. (Plate XXIX, fig. 2.)

A further improvement was made in the method of planting. Setts with three eyes were taken, as is the usual practice, and the middle eye was removed by a knife ; the sett was then placed with the remaining two eyes upwards.

Plate XXX shows the side view of the resulting crop in its early stage.

To get the maximum number of canes in the method of "two eyes up," the setts are planted at 2½′ to 3′ apart, and the distance between two setts is about 6″. This gives about 25,000 canes per acre at harvest time. It is expected that the yield of the two-eyes-up method will be better than that of the single-eye-up of last year, the former removing the defect of the small exposed sett and retaining the advantage of position of seed. The results will be available next year.

As stated in last year's paper, the uniform crop of cane obtained by the single-eye-bud method with all the eyes placed upwards suggested, with regard to the cause of unevenness in the plants in ordinarily sown field crops and the non-germination even of some

of the good seeds, that these differences may be partly due to the position in which the seeds fall in the ground while sowing. Accordingly, last year, further tests of different kinds of seeds in different positions were made.

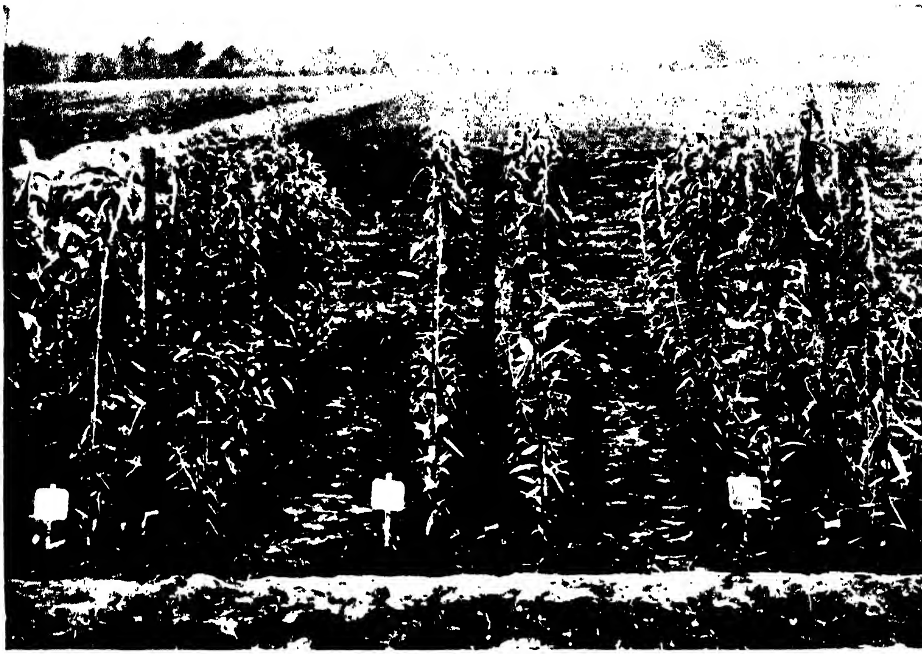
In the case of maize, seeds planted with the points upwards germinated last, and produced weak seedlings; while seeds planted with the points downwards and sideways produced healthier plants.

Point up-down-side-side. **Point side-side-down-up.**

Pot test with maize seed.

Field tests made this year on leguminous crops (*viz.*, sann-hemp, jack beans) and cotton, show that the plants produced from seeds planted with the points downwards or sideways are better than those coming from seeds with the points upwards. The results obtained in all these crops are uniform. (Plate XXXI.)

The observations made in the field experiments carried on during the current year, where seeds naturally fall deeper in the ground than in pots, showed that, as in the case of cotton described last year, the seed coat was freed in certain plants from the plumule, before appearing above ground, by the weight of the soil through which it had to force itself up. However, great variations were seen in the young plants in a field crop, some germinating early with healthy cotyledons and some coming up late with sickly seedlings though sown at the same time and under similar conditions. This induced

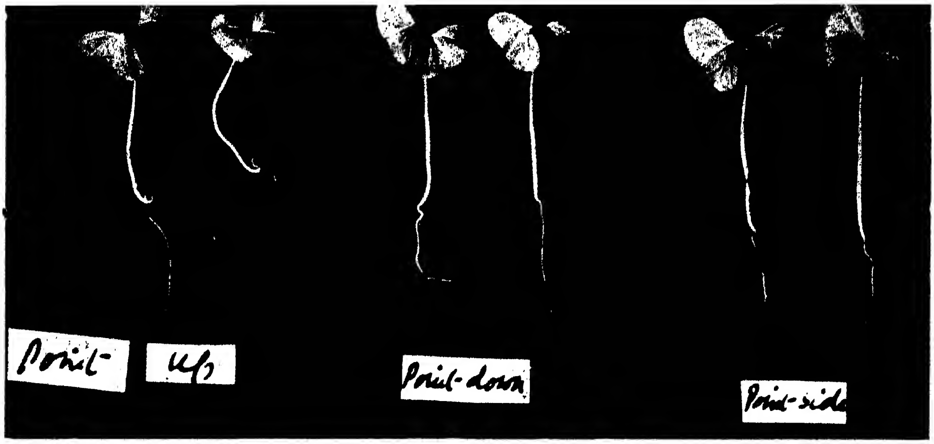


Point up. Point down. Point side.

Sann-hemp.

Point up. Point down. Point side.

Kumpta cotton, bushy type (Gokak Farm).



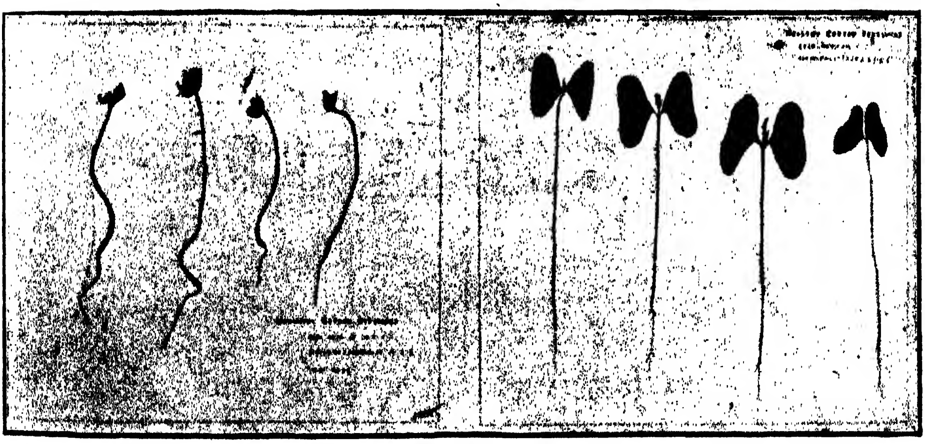
Radicle bent. Radicle straight.

Root systems of cotton plants with different positions of seed.

the writer to examine carefully both the healthy and weak plants, and it was found that, in the case of healthy plants, the radicle and the plumule form a straight line, the former going straight down and the latter coming straight up. In the weak and late seedlings radicle and plumule go in zigzag ways.

This is partly due to the improper position of the seed in the ground, and partly due to the weight of the soil over and pressure by the side which may interfere with the seedlings. Thus the plants which receive a check in some way or other while germinating remain weak for ever, and their growth is further checked by the neighbouring plants which make a healthy start from the beginning.

The following photograph gives an idea of the root system ot the healthy and weak seedlings of cotton in their early stage.



Unhealthy and healthy cotton plants from a plot ordinarily sown.

To know exactly the root system of cotton plants coming from different positions of seed, a test was made in pots, and the plants with their root systems are shown in Plate XXXII.

The root system of the seedlings, and the consequent healthy or weak appearance of the cotyledons, suggests that the unevenness of plants in crops in which seedlings are transplanted, such as chillies, brinjals, tobacco and many other vegetables and fruit trees, may be due to the improper position in which the roots are placed

in the ground while transplanting. Similarly, the unevenness in the growth of several of our cultivated fruit and other trees, and the naturally-grown timber and other forest trees, may be due to the different positions of seeds in which they are planted or fall of themselves.

Experiments on these points seem necessary.

Conclusions.

(*a*) The position of seed while sowing or planting is one among many other causes by which unevenness in plants is produced in ordinarily sown field crops, and also of the occurrence of non-germination of even some of the good seeds.

(*b*) It is possible to put the seeds in a proper position in such crops only, whose seeds or setts are dibbled or planted by hand.

(*c*) In the case of sugarcane, an absolutely uniform crop can be obtained by planting the setts with eyes upwards and by the removal of tillers.

Selected Articles

CO-OPERATIVE MARKETING.*

BY

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In a country so predominantly agricultural as India, the most vital question is not for which crops the climate and soil are most suitable, but which crops will yield the highest net return to the cultivator. The answer to the first question is to be found in the science of modern agriculture, and different agricultural departments throughout the country are trying to discover it. The second question is a problem in practical rural economics and there is as yet no school of practical rural economics in India. When communications were ill-developed and the prime object of the cultivator was to grow food for himself and his family, and a surplus to meet their other needs, marketing was simple. The surplus was sold to the nearest buyer who paid probably the least he thought the seller would take. As communications have improved, the cultivators have become less dependent upon the local market, and it has become possible to grow tea, coffee, jute, groundnuts, and cotton for export. Where this is the case there is a tendency either towards the capitalization of agriculture, as exemplified by the big tea estates, or towards dependence upon powerful middlemen. The individual cultivator is not in a position to study the requirements of distant

* **Reproduced from the *Bombay Co-operative Quarterly*, March 1919.**

markets, and his own output is too small to permit of his embarking on commercial transactions. So long as he grows staple crops, he can without much difficulty secure something approaching a fair price. Wheat, for instance, being a world crop, its price is determined at the big secondary markets, of which Liverpool is the most important. Buyers in India can calculate easily the highest price they can offer so as to leave a margin of profit, and competition secures to the producer something not far removed from this. Where, however, the crop is a specialty, namely, one for which there is no regular market quotation, the producer is at the mercy of the middleman. If the specialty be not rapidly perishable, the producer may be able to hold out for a good price ; if it be perishable, such as fruit, vegetables, etc., he is practically helpless, single-handed. The production of specialties is thus dependent on the system of marketing, and it is probably defective organization for marketing that accounts, in part, for the small outturn of high paying specialties and the devotion of so large an area to less paying staple crops, such as wheat.

Speaking very generally, Indian agriculturists are poor because they are trying to maintain by extensive cultivation a population more than sufficient for the most intensive system ; as Professor Slater has pointed out, the rural worker is unemployed for a large portion of the time. In England, one man may look after a farm of 70 acres, and three would work one of 125. In this country, there would probably be from four to nine on the first, and ten or twelve on the second. In dealing with Indian problems, it is unwise to generalize, and in dealing with questions of Indian poverty it is impossible to account for all the facts by a few causes ; but there are grounds for believing that unless the excess rural population can be occupied in industries, the hope for agricultural prosperity must lie in the evolution of a highly intensive system of cultivation which will fully employ and fully repay all the labour available. If the outturn of the present kinds of crops in the Punjab were raised to the English average, it could not suffice to feed the people on the English scale. The land, in short, under the present crops will not support the people under an improved dietary. The problem of

raising the standard of food is thus not so much only of improving the outturn of existing crops, as of evolving a satisfactory system of intensive agriculture and of selecting crops that will respond to this method. Thus both producer and consumer are intimately concerned in the question of growing specialties, and as the growth of specialties is largely dependent on the system of marketing, this latter problem is deserving of wide attention and deep consideration. Now, as Mr. Keatinge has pointed out in his "Rural Economy in the Bombay Deccan," "the marketing organization is very defective and we can only look to the co-operative spirit." Where prices are indefinite, the cultivator requires an organization to protect his interests and to secure for him all the advantages his crops can earn; and whatever a cultivator requires in the way of organization the co-operative method can usually best supply.

Co-operative marketing requires more careful organization and more expert guidance than the more simple forms of co-operative activity, such as supply and credit; it calls for more discipline amongst the members and not infrequently for a considerable outlay of capital. To ensure success, careful preliminary study is required, and, accordingly, a work which describes in much detail one of the best known examples of co-operative organization for marketing is most welcome. In his "Co-operative Marketing,"[1] Mr. Cumberland has successfully attempted to draw an accurate picture of the actual operations of the series of organizations that form the distributing system of the California citrus-growers. The subject has already been dealt with in somewhat less detail in Mr. Powell's "Co-operation in Agriculture," but there is room for this more elaborate account, in view of the vast importance of creating a comprehensive system of distribution that shall be at once efficient and cheap. When the public buys food it is paying the middlemen and retailers as much to supply it as it is paying the cultivators to produce it; the consumer gets too little for his money and cannot afford to buy more, demand is thus restricted and greater supply is discouraged. There

[1] "Co-operative Marketing," by W. W. Cumberland, Ph.D., Assistant Professor of Economics, University of Minnesota.

is at present much grumbling against high prices which should be directed against high charges for distribution. The expression "high profits" is avoided, as it is doubtful if the Indian middlemen get such profits as some people think, owing to their defective methods and lack of proper organization. Somehow, the sight of an Indian middleman or retailer poring over books on marketing or studying prices in different towns and the cost of sending goods there is not common. The average member of this class could not read the books or understand the railway tariff, and his educated son becomes a pleader instead of an expert distributer. Marketing efficiency requires specialized skill, extensive information, and wide knowledge. The expert potato-grower, the owner of a fruit garden, or the industrious market-gardener around the big towns is usually profoundly ignorant of the general market situation. If he wants to know the price of a thing he will enquire from some one seeking to buy or from a friend who has just sold ; if he were told that he could get a better price at some distant town he would not know how to dispose of his crops there. He pours his produce into the nearest market which for him is not unseldom the worst. Of the advantages of warehousing, storage for a better price, preservation to last over a glut, etc., he knows but little. Of grading in order to secure a higher price for better produce he has little idea. The result is all round inferiority and waste. A cultivator is not likely to expend much effort on growing finer vegetables or better fruit, or on breeding a higher class of poultry, unless he is reasonably assured of an extra reward over and above what his less enterprising neighbour receives. In the Punjab, there was at first considerable difficulty experienced in getting a higher price for long staple American cotton. The Agricultural Department first started the auction system, and now co-operative sale societies are being formed to hold auctions. At the first co-operative sales held this season, the staff graded the cotton under the guidance of agricultural experts and the resulting classes were auctioned separately, and the prices obtained varied with the purity of the cotton. The result is that cultivators are prepared to uproot from their fields any *desi* cotton plants that have got mixed up with the American variety. Until the American type obtained a higher

price than the old short staple variety, cultivators hesitated to grow it ; now the difficulty is to supply sufficient pure seed to meet the demand.

The lack of proper marketing organization may again be illustrated by reference to Punjab oranges. The province grows a fine orange known as " malta," but there is no attempt to place it on the market on a modern system. There is no grading, and hence there is no inducement to the growers to look after their trees, prune and manure them, and improve the fruit. There is little attempt to find a wider market, and hence the production is far smaller than it should be. The garden-owners usually sell the crop on the trees to a contractor and seem quite satisfied with the price. There is practically no attempt to store, though the orange being hard-skinned keeps well, and the whole produce is thrown into the towns as it ripens. What the industry might develop into, if thoroughly well organized on the lines of the California Cotton Growers Association, can only be guessed. One very important advantage to be obtained from an efficient system of co-operative marketing is the reconciliation of the two factors mentioned at the beginning of this article. For the crop for which the climate and soil are most suitable will tend to pay the cultivator the highest return if he can secure a full price of it. The adoption of business principles in agriculture will relieve the cultivator of the necessity of growing food for his family on soil that is better adapted to something else. He will be able to concentrate on the most profitable crop and to buy his food from lands better adapted to grow it. In a country of small holdings this is of great importance. The average Punjab peasant is poor on eight acres, the Californian fruit-grower is prosperous on fifteen. The former grows a variety of crops, some to eat, some to sell, some for his cattle, and some, like hemp, for the needs of his industry. He is expert in the growing of none. The expert fruit-grower can develop a high technical skill. The problems of irrigation, cultivation, fertilization, protection from pests, eradication of disease, etc., of a single crop are many, but they are less numerous than the same problems for a series of crops, so that while only the most highly trained may hope to cope with the latter, a good intelligent

cultivator should be able to acquire a sound practical knowledge of the former. High technical skill warrants the investment of considerable capital, and the cost of cultivating an acre of oranges varies from Rs. 260 to Rs. 600 a year. Obviously, with so much at stake and so much to recover, the problem of sale is of far greater importance than it is in the case of a staple crop of which the current price in the chief markets is always easily ascertainable. The price of wheat being more or less fixed by factors independent of the cultivator, the latter has to seek increased profit by increasing his production without an equal increase in cost. But in the case of a specialty the price obtained is largely dependent on the methods of marketing. If the middlemen will serve the producer honestly and well, the latter is not likely to combine, but experience shows that if the producer desires to be served honestly and well he must serve himself, in other words, he must co-operate, and if he once decides to co-operate, he will gradually gain all the advantages which large-scale efficient organization can give. Of the form of the organization that has grown up in California it is unnecessary to give details. It follows closely co-operative principles as practised elsewhere. The 'one man one vote' rule is modified to meet the circumstance that one man may have a five-acre orchard and another one of 100 acres, and votes vary with the acreage under fruit. Further, membership goes with the orchard and not with its owner. Thus a member who sells his orchard ceases to be a member. The object is to serve the growers at the actual cost of the service, and no profits are sought to be made; the "dividend malady" is thus avoided.

The actual results of the co-operative organization have been remarkable. The cost of packing has been reduced so that something approaching ten crores of rupees has been saved to the producer in twelve years; by the exercise of organized bargaining, railway rates have been reduced, resulting in a saving of fifty lakhs of rupees a year; commission on sales has been reduced from 7 or 10 per cent. to the actual cost of 3 per cent.; losses from failure to recover the sale money have been eliminated. Where the individual grower is unable to afford the time, trouble, and expense involved

in presenting a claim for damage in transit against a railway or transport company, the big organization does it for him with ease and success, and railway servants have learned in consequence to handle the goods with greater care. A further great advantage has resulted from the considerable improvement in cultural skill which the organization has encouraged. It has been possible to secure expert investigation into the various difficulties and to make the results known to the growers; great success has been attained in eliminating waste due to delay; the causes being discovered, the members have been enjoined to avoid the mistakes responsible for this source of loss. The biggest task was to find new markets to permit of enhanced production and to supply them so as to secure a good price without frightening the consumer; this was in some ways the most difficult of all, but careful study and collection of information solved it. For detailed descriptions of the methods adopted to secure these results, the reader is referred to Dr. Cumberland's book. The essential element is organization on co-operative lines, and no one acquainted with conditions in this country will be prepared to doubt that extremely valuable results await well-directed effort here. The field is immense, but comparatively speaking it is empty of workers. The commercial and trading classes show little capacity for organization. Their methods are as backward in their own business as are those of the cultivator in his. We have thousands of pleaders, but no expert market organizer, hundreds of books on Indian law, but hardly a dozen of any merit on rural economics. We are told that fathers can find no employment for their graduate sons, while numerous factors producing poverty and disease lie around neglected. To all with the leisure to read and the desire to help India, we can commend Dr. Cumberland's "Co-operative Marketing" as a study in the practical promotion of prosperity by methods open to all.

ECONOMIC CONDITIONS IN SOME DECCAN CANAL AREAS.*

BY

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THE canal areas in the Deccan have features of intense importance to co-operators in Western India as well as to all others who have an interest in the economic development of the country. Some of these, so far as I can judge, are unexpected, but the possibility of their being repeated in future similar conditions makes their study worth while at the present moment.

The greater irrigation canals of the Deccan are four, and their relative characters are as follows. I have, in each case, in order to compare the size, indicated the area of "four months' crops" which they are calculated to be able to support :—

(1) The Gokak Canal, which cost 19 lakhs of rupees, and is capable of giving water for 10,000 acres of four months' crops.

(2) The Mutha Canal, opened in 1873–78, which cost 115 lakhs of rupees, and is capable of giving water for 49,000 acres of four months' crops. (As this canal also provides the water-supply for Poona, neither the cost nor the area is comparable with the others.)

(3) The Nira Canal, opened in 1884, costing 99 lakhs of rupees, and capable of irrigating about 100,000 acres of four months' crops.

(4) The Godavari Canal, recently opened, and capable of irrigating about 57,000 acres of four months' crops.

* Reproduced from the *Poona Agricultural College Magazine*, April 1919.

All these lie in tracts of very small and variable rainfall, most of the character of the rain coming, when it does come, in heavy storms of short duration. Except for the Gokak area, the rainfall varies from twelve inches upto about twenty-five inches per annum, but is generally under twenty inches over the much of the area. As a result of the rainfall, the hill-tops and high lands, as well as the upper portions of the slopes, are usually washed almost free of any fine soil, and hence there are on these positions very shallow stony lands. The drainage channels are deep and highly scoured. On the other hand, however, the valleys are filled with soil of good quality, whose depth largely depends on the narrowness and steepness of the valley as a whole. Previous to the advent of the canals, the wells were usually deep, and irrigation, while it existed in favoured areas, was comparatively uncommon. We have, therefore, in these areas, tracts of country, which before the construction of the canals were famine-stricken and poor, where a fairly good crop could be looked for certainly not more than one year in three, where the ordinary dry crops of the Deccan were grown, where labour was superabundant and went outside to find work, where land was cheap and manure (as in all dry-crop areas in the Deccan) little used, where the villages were small and poverty-stricken but fairly healthy, and where little capital or credit existed.

These remarks apply to all the tracts in question. In what follows, however, I am going to speak more particularly of the area covered by the Nira canal, which was not only one of the earlier canals, but was brought to a country where irrigation was a new thing, and where it has now existed long enough to enable us to judge of its economic effect. I know this valley well, and I can speak largely from my own knowledge and experience, while to co-operators it has a special interest as it has been, and is, a special field for the activity of the Bombay Central Co-operative Bank. In the year 1884, the Nira canal was opened, and the effect on the district which is covered was almost immediate. I have calculated the figures for the area under sugarcane and under gardens, and also the area carrying two crops a year in the Bhimthadi Taluka (where the greater

part of the Nira canal area is situated) at various times, and they are as follows :—

	Area under sugarcane	Area under garden crops	Area double-cropped
	Acres	Acres	Acres
1885-86	415	999	7,981
1890-91	675	2,656	14,464
1895-96	2,690	1,423	8,165
1901-02 *	5,823	2,346	19,975
1905-06	5,203	1,820	16,665
1910-11	6,229	1,246	9,626

* I have taken this year instead of 1900-01, as the latter was the year of one of the most severe famines in the Deccan, and this rather vitiates comparison with it.

The effect of the introduction of the canal on the agriculture of the area was not, in the first place, a very large increase in the amount of sugarcane, but rather an increase in the crops the people had been usually growing, like vegetables, and a larger use of double-cropping. In other words, it was a continuance of previous practice, though on a more intensive scale. But little by little it became evident that sugarcane was capable of yielding, under irrigation, greater returns than such garden crops or than such double-cropping, and very gradually the amount of sugarcane increased. This was partly due to the enterprise of the people themselves, but also, in a considerable measure, to the incoming of a group of cultivators—the Saswad *malis*—who rented the land without any idea of purchasing it, but who were expert sugarcane growers and who knew how to make large amounts of money by it.

It will be seen, however, that from a tract of intensive cultivation, the Nira valley canal area tended to become a land of one crop. Garden cultivation has declined, and the double-cropped area is now little greater than before the advent of the canal. That one crop, however, was an exceedingly valuable one and, when well cultivated, gave very large returns. Hence, the land capable of being irrigated and of growing sugarcane rose rapidly almost to ten times its former value. Areas, formerly saleable for Rs. 50 to

Rs. 100 per acre, became worth from Rs. 500 to Rs. 800, and the result was an enormous expansion of credit.

This very large increase of credit was, however, fully needed. Intensive cultivation of whatever kind leads to a very large demand for money. In the present case the demand was extreme, for, as grown in the Deccan, sugarcane needs more floating capital per acre than almost any crop that I know. A man is considered to be unwise who spends less than Rs. 500 per acre on a single year's crop. This demand for money, accompanying the rapid rise in the price of land, caused a large number of financiers or money-lenders, who usually follow closely the growth of high-class crops, to settle in the district. It will be seen that the presence of such financiers was necessary, but, as usual, when advancing money on a crop, they have charged a very high rate of interest, and bargained to act as brokers for the sale of the *gur* or *jaggery* from the cane. The usual rate of interest in the Nira valley for advances on the cane crop has been 18 per cent., the usual brokerage rate for selling the produce, I am informed, has been 8·6 per cent.

If I may digress a little, I should like to call attention to two other indirect economic results of the bringing of canal water into the Nira canal area. The first is that it allows much greater subdivision of the ownership of the land to take place than would otherwise occur. Subdivision, to an excessive extent, is at present one of the great banes of Deccan agriculture. But subdivision in practice, if not in theory, must stop when the areas owned are not worth owning. By increasing the value of the land you can make the subdivision of ownership much greater than it was before. The second indirect result has been the creation of a feeling that actually to work on one's holding is rather beneath the dignity of a landholder, and while, before the appearance of the canal, nearly all cultivators would plough and cultivate their own land, it is now usual for almost all but the very small growers of sugarcane to carry on nearly all agricultural operations by means of labourers. There is, therefore, a greater and greater tendency to depend on labour.

These matters are, however, by the way. The general progress was as follows :—Sugarcane cultivation was found to be capable

of giving very high returns. This led to very largely increased land values, and hence to greatly expanded credit. This, again, led to the greater concentration of effort on the one crop, namely, sugarcane, which was able to give the highest returns.

Now, dependence on one crop is always a risky thing. It is risky because the variations in price of a single article (in this case, *gur* or *jaggery*) may be so great as to destroy a large part of the profit, and the crop, in this case, is on the land so long that there is little chance of a change in price being foreseen. It is also risky because a single crop is always liable to be attacked with disease or destroyed by unfavourable weather conditions, and, finally, it is risky because land is always liable to deteriorate when grown continuously or frequently to one particular crop. These risks may perhaps be faced with equanimity if a man is using his own capital, but if he is paying over 20 per cent. (including the brokerage) per annum for the capital he is employing, and if, in addition, the capital required is very great indeed, the risky nature of the cultivation is much emphasized.

In the present instance, the price has proved much more constant than might have been expected, though there was a time, about ten years ago, when it fell almost to the cost of production. The crop also has been, on the whole, very reliable, and the diseases which have ruined the crop in many other places have not done fatal damage in the Nira valley. The land has, however, in many places deteriorated badly, and this deterioration is, if my information is correct, still going on.

In an area of arid land, brought under irrigation, there is always a tendency for an accumulation of salt to take place on the surface of the land, unless drainage is particularly good. And this is particularly the case if the irrigation is intensive, and if the subsoil, formerly dry, becomes filled up with seepage from the canal or from the irrigated fields. Now, with the increase of sugarcane cultivation, the irrigation became more and more intensive, little attention was paid to drainage either by the canal authorities or by the people, the subsoil became more and more filled with water, and the land became more and more injuriously affected by salt. In many cases,

the salt increased so much tha tthe land went out of cultivation. Over five thousand acres of formerly cultivated land under the Nira valley is now useless. But, in many cases, even where the amount of salt is not sufficient to cause crops to fail, it becomes more and more difficult to obtain a first-class crop, more and more manure is required for the purpose and, hence, the already very high cost of cultivation tends constantly to increase. Closely connected with this matter, too, is another factor which has had, I believe, a very economic effect. The rise in the subsoil water has made the canal area unhealthy, and what was formerly a district very free from malaria is now one of the most malarious in the Deccan.

We have, therefore, following on the great concentration of effort, capital, and water on one crop—sugarcane—a large increase in credit, a large amount of money in circulation, a large return on capital if all went well, but a condition of things very risky for all but the most financially stable of the sugarcane growers. A year's lack of success places them in the hands of their financiers, from which they can only hope to escape by growing again the same crop. In the meantime, the expense required to get a first-class crop has been getting greater and greater, and hence the chance of a man who once made anything but a brilliant success of any particular crop getting over again into financial independence has been becoming less and less. The charges for interest and brokerage have, in fact, been so great, and the chance of the crop giving the highest yield has been getting less to such an extent, that it has been increasingly difficult for a man using other than his own capital to make his crop pay.

There has, in fact, been a tendency for the richer men in the valley who work on their own capital, still to make good profits though they acknowledge these to be much less than formerly. Many of the best of these, chiefly the Saswad *malis*, have departed to the more virgin land under the Godavari canal. Those who remain, however, still do well, tend to accumulate capital, and give an appearance of prosperity to the valley to an outsider. The much larger number, who are dependent on advances for growing their crop but who cannot cease growing it without definitely abandoning

their land to their financiers, are, I believe, not making money, but becoming poorer and poorer, and tend to be financially more involved every year.

This may be a somewhat gloomy picture of a valley, where the canal has brought so much wealth, has changed a desert into a garden, and has obtained so many advantages for the people. And I do not wish to exaggerate in the matter. Sugarcane cultivation will still give good returns with skilful and careful management. But the days when these returns could be got while paying for financial aid at the rate which has been customary are, I believe, gone. To make the industry pay in future will mean far more attention to drainage than in the past, far more care for levelling, far more trouble to get the best seed, far more skill in the selection and use of manure, and attempts (as for instance, by the use of the Manjri method of cultivation) to reduce largely the present cost of cultivation.

I expect the course of events will be more or less the same on nearly all canals, and especially on those which devote themselves to the cultivation of one particular highly profitable crop. Some men will succeed and become rich, others and the vast majority may also do well for a time until the causes I have tried to describe become operative, and they find a declining crop, which they must still cultivate, leading to hopeless financial bondage. To introduce at this stage improved credit facilities may help little, unless at the same time you bring in such agricultural improvements as will lower the cost of production, or increase the yield, or improve the quality, so that temporarily, at any rate, the return to the grower may be raised to the old rate. Then, and only then, will the improved credit facilities become really operative, and enable the cultivators who have been almost swamped, to recover their economic independence.

THE POSITION OF THE EUROPEAN SUGAR INDUSTRY AT THE END OF THE WAR.*

BY

H. C. PRINSEN GEERLIGS.

THE production of sugar in the European countries is again smaller this year than in the foregoing year, and still continues its downward course, as the table given underneath clearly shows :—

Tons of 1,000 *kilos.*

Countries of production	1913–14	1914–15	1915–16
Germany	2,718,000	2,564,000	1,600,000
Austria-Hungary	1,688,300	1,619,000	938,900
France	781,000	295,000	150,700
Russia	1,688,000	1,939,000	1,667,400
Belgium	229,000	160,000	113,100
Netherlands	231,400	295,000	242,800
Sweden	137,200	154,000	127,300
Denmark	145,700	150,000	125,000
Other countries	542,800	500,000	300,000
TOTAL ...	8,161,400	7,676,000	5,265,200

Tons of 1,000 *kilos.*

Countries of production	1916–17	1917–18	1918–19
Germany	1,500,000	1,600,000	1,400,000
Austria-Hungary	935,000	700,000	900,000
France	207,000	200,000	100,000
Russia	1,325,000	1,000,000	700,000
Belgium	135,000	150,000	100,000
Netherlands	266,000	200,000	160,000
Sweden	118,000	120,000	100,000
Denmark	114,000	200,000	115,000
Other countries	250,000	200,000	240,000
TOTAL ...	4,850,000	4,290,000	3,805,000

* Reprinted from the *Louisiana Planter and Sugar Manufacturer*, vol. LXII, no. 9.

The causes of this decline are situated only for France in the direct consequences of the war, because in that country numerous sugar houses have been wrecked or damaged or dismantled to such an extent that out of the 206 factories existing before the war, only 61 have been able to do work in this year. It is quite certain that even after the conclusion of peace a large number of the idle ones will no more be rebuilt, which is to a great extent due to the fact that the constructing shops in France have also been deprived of their machinery by the invaders.

In all the other European sugar-producing countries the indirect consequences of the war have occasioned the sharp decline in the production. In the first place, the lack of supply of foodstuffs and fodder from overseas has stimulated the agriculture of potatoes, breadstuffs, oilplants and the like to the detriment of that of sugar beets, while also the area planted with swedes, turnips and similar hoe-crops has been greatly increased, bringing along a reduction in that devoted to sugar beets.

In many instances this decrease in the area planted with beet has been made voluntarily by the growers, but in many other cases they were compelled to do so by Government regulations. Except the necessity of cultivating direct food plants, which fetch a high price and for that reason present a certain attraction, other circumstances co-operated to decrease the beet sowings still more. The beetroot requires an intensive labouring and manuring of the land and much care and weeding, in order to produce a remunerative crop, which requirements are difficult to satisfy in times of scarcity of people, horses, fertilizers and implements. Further, the beetroot is the latest crop in the year, being only ripe and saleable at a time when all other crops have already been disposed of. Finally, the beetroot wants to be pulled and hauled away within a very short space of time. As soon as the beets are ripe, they have to be carted off before the frost will retard or even prevent pulling and transportation, and if labour is short and means of transport not adequate, the crop may lose in quantity and in quality. All these reasons have induced many a farmer to restrict his beet sowings as far

as is still in agreement with the need of pulp for his cattle or the requirements of his rotation of crops.

The planted area was, therefore, much smaller than in normal times; next, the output per acre of sugar on 100 parts of beets, too, is less, thereby decreasing the sugar crop for all these three reasons. The shortage of labour and of fertilizers caused the output per acre to be less than in other years, when every care had been bestowed to the growing crop. The lack of fodder for the cattle induced the farmers to cut off large pieces of root, when removing the heads and leaves, and to keep back small beets too for cattle food, thereby reducing still more the portion of their crop coming to the sugar house. Finally, many beets were used for the manufacture of coffee substitutes and for alcohol, which together resulted in a serious shortness of material for the sugar production.

The sugar-content of the beets in the field was not a high one, as a consequence of the small amount of tillage and weeding which had been done by the deficient labourers, and further the delayed pulling and transporting caused that small sugar-content to go down still more before the roots could be worked up. The lack of coal compelled the sugar houses to work slowly and with shorter or longer interruptions, all circumstances which decreased the rudiment of sugar from the beets. Finally, the shortage of fodder brought along the necessity of producing as large a molasses output as possible, and the price of sugar in molasses was so much higher than that in the ready article, that the manufacturers left as much sugar behind in the molasses as they possibly could and thereby decreased the output of sugar on 100 parts of beet. In countries where, before the war, sugar was extracted from molasses, this process was forbidden now, also in order to leave as much molasses available for cattle food as possibly could be obtained.

Besides all these reasons, there is still a very bad factor in Russia, where since the revolution the conditions for work are so bad and so disturbed that it is not clear how matters will come to their own again. In the part of the land still belonging to the old Russia, the production of sugar has come down from 300,000 tons to a mere 70,000, while in the other parts as Ukraine and Poland

the crop appears to be about one-half of the former figure, but no reliable data are to be had and the figure in the list is only an approximate one.

On the other hand, the consumption of sugar has been greatly increased, and had to be contingented if the nations did not want to be threatened by a complete absence of that article a long time before the advent of a new crop. The armies and navies consumed much more than their individual members would have done if they had been allowed to remain in their quiet civilian occupations, and further a not inconsiderable quantity of sugar was used as a raw material in the manufacture of explosives.

The civilian population, too, extended its sugar consumption, because of the lack of butter and fat to be smeared on bread and because of a great many other articles of diet having vanished from the bill of fare. The bad, grey and unpalatable bread had to be combined with honey, jams, marmalades and the like in order to be able to be eaten with the least possible amount of disgust, and all this demanded sugar and sugar again. It soon became evident that where the home production failed, the importation from abroad was rendered impossible either by the blockade or by the U-boat warfare or by both, and where the requirements for the armies and navies had to be satisfied above all, the consumption of the civilians at home had to be greatly rationed in every European country, while the amount of sugar put at the disposal of the industries using sugar as a raw material was cut down in most places to one-fourth of that in peace times.

At the end of the great war, at the moment of the signing of the armistice and of the beginning of peace negotiations, we see in Europe a bad sugar crop just ended, with very short stocks from the foregoing crop and very very little chance of importing sugar from overseas save for England, France and Italy. A severe scarcity of sugar is to be added to the already existing shortages of fat, bread, meat, coffee, tea, spices, fodder, milk, in short, of every article of food, and no visible way of escaping famine.

Moreover, in various countries voices are heard advocating the monopoly by Government of the sugar trade, thereby levying a

high duty on sugar as a means to pay off interest and amortization of the war loans, and where a monopoly is not yet planned, a great increase of the sugar duties is contemplated, also with a view to increase the revenue of the Exchequer. The consequence of both measures will certainly be a restriction of the sugar consumption in the countries concerned.

The prospects of the European sugar industry are anything but bright, and although the armistice is concluded and perhaps peace is at last in sight, the various reasons enumerated above, which have co-operated to decrease the production, will last still a very long time and will very probably keep the European sugar production at a much lower level than it used to occupy in the happier days before the dreadful war.

INCREASED YIELDS AS THE RESULT OF SWELLING SEEDS IN WATER.

THE following note communicated by Dr. Franklin Kidd and Dr. Cyril West, of the Imperial College of Science and Technology, is reproduced from the *Journal of the Board of Agriculture*, Vol. XXV, No. 11:—

Much interest has been aroused recently amongst agriculturists as to the possibility of obtaining increased yields from seeds which have been submitted to treatments in which soaking in water or in salt solutions plays a part. It, therefore, seems appropriate to draw attention to this subject.

Some 40 years ago two German agriculturists of repute, namely, C. Kraus[1] and E. Wollny [2], [3] showed that increased yields could be obtained by swelling seeds in water.

Their main conclusions may be summarized as follows :—

(1) In order to obtain the best results the seeds must be swollen in the minimum amount of water necessary to saturate the seeds thoroughly. (If a large excess of water is used, the effect upon the subsequent growth and yield of the plants may be harmful.)

(2) The time of immersion should be sufficiently long for the seeds to become fully swollen.

(3) A subsequent redrying of the seed does not appreciably alter the beneficial effect of the treatment, but the redrying must not be carried out too rapidly.

[1] Kraus, C. "Untersuchungen uber innere Wachstumsursachen und deren kunstliche Beeinflussung." Wollny's *Forschungen auf dem Gebiete der Agrikultur-physik*, I—IV, 1878-1881.

[2] Wollny, E. "Untersuchungen uber die kunstliche Beeinflussung der inneren Wachstumsursachen, VII, Der Einfluss des Vorquellens des Saatgutes auf die Entwickelung und die Ertrage der Kulturpflanzen." Wollny's *Forschungen auf dem Gebiete der Agrikultur-physik*, VIII, 1885, p. 380.

[3] Wollny, E. "Saat und Pflege der landwirtschaftlichen Kulturpflanzen." Berlin, 1885.

(4) The percentage of germination is liable to be slightly decreased by the treatment.

(5) Swelling seeds in solutions of nutrient salts has much the same effect upon yield as swelling the seeds in pure water.

(6) All the seeds tested (*i.e.*, the chief cereals and various other annuals of economic importance) gave the same result, with the exception of winter rye.

As the published results obtained by these agriculturists are accessible at only one or two libraries in this country, we may profitably record here a few of their figures.

TABLE 1.—(After Wollny).

Comparison of yields from (i) seeds swollen in water and sown in the moist condition, (ii) seeds swollen and redried before sowing, and (iii) untreated seeds.

The seeds were allowed to swell in the least possible amount of water necessary for complete saturation for 36 hours (the maize for 72 hours). The redrying process extended over 14 days, during which time the seeds were left exposed to the sun and air.

Kind of seed	Date of experiment	Treatment of seed	Number of plants: Original	Number of plants: At the harvest	Yield from 100 plants: Seeds	Yield from 100 plants: Straw	Average weight of 100 seeds	Percentage increase or decrease in yield of seeds from experimental plants as compared with that from the controls
					grm.	grm.	grm.	
Victoria peas ...	1877	Swollen, sown moist ...	64	58	532·9*	1324*	...	+ 29
		Untreated ...	64	59	413·3*	1443*	...	......
Beans ...	1877	Swollen, sown moist ...	64	57	920·5*	2436*	...	+ 27
		Untreated ...	64	60	727·6*	2215*	...	......
Victoria peas ...	1878	Swollen, sown moist ...	100	88	1188·6	1778	...	+ 23
		Untreated ...	100	94	967·0	1658	...	......
"	1882	Swollen, redried ...	92	74	548·6	1594	...	+ 9
		Untreated ...	97	76	502·6	1684	...	......
Vetch ...	1882	Swollen, redried ...	90	79	440·4	910	...	+ 6
		Untreated ...	96	82	417·0	1074	...	......
Winter rye ...	1882	Swollen, sown moist ...	100	96	867·0	1510	...	− 6
		Untreated ...	100	100	925·0	1690	...	......

* Yield from 64 plants.

TABLE I.—(After Wollny).—*Continued.*

Kind of seed	Date of experiment	Treatment of seed	Number of plants: Original	Number of plants: At the harvest	Yield from 100 plants: Seeds	Yield from 100 plants: Straw	Average weight of 100 seeds	Percentage increase or decrease in yield of seeds from experimental plants as compared with that from the controls
					grm.	grm.	grm.	
Victoria peas ...	1882	Swollen, sown moist ...	95	84	602·0	2012	...	+ 10
		Untreated ...	97	90	548·0	1998	...	......
Vetch ...	1882	Swollen, sown moist ...	89	87	414·0	1138	...	+ 7
		Untreated ...	98	89	388·0	1146	...	......
Victoria peas ..	1883	Swollen, sown moist ...	69	62	445·0	1355	...	+ 16
		Swollen, redried ...	79	71	511·0	1408	...	+ 34
		Untreated ..	93	83	382·0	952	...	......
Beans ...	1883	Swollen, sown moist .	99	99	869·0	1545	46·5	+ 9
		Swollen, redried ...	100	96	868·0	1459	45·6	+ 9
		Untreated ..	99	94	798·0	1468	38·8	......
Winter rye ...	1883-4	Swollen, sown moist ..	99	60	1160·0	1983	2·99	— 8
		Swollen, redried ...	95	83	1101·0	1831	3·17	— 13
		Untreated ...	93	70	1263·0	2314	3·14	......
Summer rye ...	1884	Swollen, sown moist ...	94	80	497·0	975	2·75	+ 5
		Swollen, redried ...	85	53	559·0	1302	2·38	+ 18
		Untreated ...	89	78	475·0	1051	2·57	......
Maize ...	1884	Swollen, sown moist ...	27	27	12515·0	46740	38·9	+ 11
		Swollen, redried ...	27	26	14792·0	47577	36·1	+ 31
		Untreated ...	27	27	11274·0	41630	36·4	......
Victoria peas ...	1884	Swollen, sown moist ...	96	92	730·0	1282	27·9	+ 9
		Swollen, redried ...	92	87	705·0	1310	29·4	+ 6
		Untreated ...	94	87	668·0	1184	28·7	......
Beans ...	1884	Swollen, sown moist ...	95	77	381·0	766	47·2	+ 3
		Swollen, redried ...	95	82	402·0	792	51·0	+ 9
		Untreated ...	94	80	369·0	725	47·7	...

TABLE II.—(After Wollny).

The harmful effect of soaking seeds in excess of water.

In these experiments the volume of water used was ten times that of the seed.

Kind of seed	Treatment of the seed	Number of plants at the harvest	Yield from 100 plants: Seeds	Yield from 100 plants: Straw	Average weight of 100 seeds
			grm.	grm.	grm.
Summer rye ...	Untreated	78	475	1051	25·7
	Soaked	65	359 (—24%)	877	22·7
Peas ...	Untreated	87	668	1184	28·7
	Soaked	84	546 (—18%)	1214	27·5
Beans ...	Untreated	80	369	725	47·7
	Soaked	77	264 (—28%)	766	54·4

From a careful analysis of the growth of the plants at various stages of development, conclusions were drawn as to the reason for the increased yields obtained. The plants from the treated seeds grew more quickly in the first few weeks, came into flower earlier, flowered for a longer period, and ripened off more slowly than the plants from the untreated seeds.

Schleh[1] and Eberhart[2] have later claimed to have demonstrated that the swelling of seeds before sowing will increase the crop yield. The following table gives one set of results obtained by Eberhart in a field experiment with beans.

TABLE III.—(After Eberhart).

Comparison of yield from (i) seeds swollen in water and sown in the moist condition, (ii) seeds swollen and afterwards redried, and (iii) untreated seeds.

Harvest results.

	Number of plants*	Weight of pods	Weight of straw	Average length of the stem	Average number of pods per plant	Weight of seeds
		grm.	grm.	cm.		grm.
Untreated seeds	96·0	609·0	776·0	97·75	4·19	474·3
Seeds swollen in water previous to sowing.	96·6	697·8	877·6	103·02	5·08	543·3 (+15 %)
Seeds swollen in water and re-dried before sowing.	95·3	677·1	875·6	101·74	5·0	526·3 (+11 %)

* Mean of three experiments.

The work referred to above indicates that a definite increase in yield may be obtained by swelling the seed in water. It is clear that the water factor must be taken into account in the consideration of any process for increasing crop production which involves soaking the seed.

[1] Schleh. "Steigerung der Ernteertrage durch Impragnation des Saatgutes mit konzentrierten Losungen von Nahrsaltzen." *Fühling's Landw. Ztg.*, LVI, 1907, p. 33.

[2] Eberhart, C. "Untersuchungen uber das Vorquellen der Samen." *Fühling's Landw. Zg.*, LVI, 1907, p. 159.

Elsewhere[1] the literature dealing with this water factor is critically reviewed, and also that dealing with the effect upon yield of the environmental conditions of the seed before harvesting, during storage, before sowing, and at the time of germination

[1] Kidd, F., and West, C. "Physiological Pre-Determination: The Influence of the Physiological Condition of the Seed upon the Course of Subsequent Growth and upon the Yield." *Review of Literature, Chapters I-IV, Annals of Applied Biology.*

THE ACTION OF MOULDS IN THE SOIL.*

THE term "mould" is applied to various species of fungi isolated from the soil, which belong to widely scattered groups, and no sharp limitation is to be placed on the use of the term.

The importance of the action of moulds in the soil has been the subject of investigations by Selman A. Waksman, of the Department of Soil Bacteriology, New Jersey Agricultural Experiment Station, and he has recorded the results he obtained in a paper in *Soil Science*, August 1918. The question is of general interest to agriculturists in relation to soil fertility; a résumé of the paper is therefore given below.

When a group of micro-organisms is studied in relation to soil fertility, the question is—What part do they play in the nitrogen changes in the soil, produced as a result of their activity? From the early period of investigations on the microbial inhabitants of the soil, up to four or five years ago, the attention of soil bacteriologists was chiefly directed to the study of bacteria, neglecting other groups of micro-organisms to which the term moulds is applied. It has only been in very recent years that the great abundance of other micro-organisms, besides bacteria, in the soil has been demonstrated, and an attempt made to explain their part in soil fertility.

It has been definitely established that moulds, together with protozoa, algæ, etc., are common inhabitants of the soil, and form a large and important group of the soil flora. Hundreds of species of moulds have been isolated from the soil, and it has been found that many moulds occur in different soils under different topographic, climatic, and soil conditions. The same species has been isolated from soils in different European countries and from soils in various parts of America. New species, never met with before, have been

* Reproduced from *Agricultural News*, vol. XVIII, no. 438.

isolated from soil, serving as a proof that some of them at least are typical soil organisms.

It has also been found that moulds develop readily in acid soils, and are more active in forest and in compact poor soils, while bacteria predominate in loose soils rich in nutrient matter, cultivated and fertilized. In fact, in well cultivated lands containing relatively little humus, bacteria play a very important part, and occur in great numbers, and the moulds are of minor importance; while the upper layers of soil in forests, rich in humus as they are, contain a large number of moulds. In rainy seasons also the surface growth of moulds is greatly favoured; otherwise they live and produce spores below the surface among the vegetable residues and the living plant roots. It has been demonstrated that not only are moulds present in the soil, but that they actually live there, and produce mycelia, which necessitates their taking an active part in the different biological transformations of the soil.

Thus to be able to interpret the part played by these organisms in the soil, they must be studied as living organisms, which by their metabolic processes help in the various transformations of both organic and inorganic soil constituents, and in this way influence soil fertility.

The question of nitrogen fixation by moulds seems to be that, with the exception of some rather rare organisms, typical soil moulds do not play any direct part in the nitrogen enrichment of soils. Nor has the formation of nitrite or nitrate ever been demonstrated for any of the moulds, so that these important activities must be eliminated from the field of mould action.

On the other hand, the moulds are found to play a very important part in the disintegration of organic matter in the soil, particularly in the first stages of decay, which is termed ammonification. Whatever may be the process of formation of complex proteins by moulds, it is certain that ammonia is left in the medium as a waste product. If available carbohydrates are present, only small quantities of ammonia will be liberated by the action of bacteria and moulds; but in the absence of available carbohydrates there is a large amount of nitrogen left in the medium by their action. If the

ammonia is regarded as an indication of the amount of organic matter decomposed by a living organism, some of the moulds commonly occurring in the soil are found to possess greater powers of decomposing organic matter than are possessed by bacteria. The action of the moulds on the nitrogenous organic matter in the soil may be said to consist in the mineralization of that material with the production of ammonia and the building up of fungus proteins. The ammonia is used by the higher plants as such, or is oxidized by nitrifying bacteria into nitrates, and so used by plants, or is absorbed again by the micro-organisms of the soils.

The moulds also play an active part in the decomposition of cellulose and other carbon compounds in the soils. This is of great importance, since both green and animal manures, and all vegetable residues, need to be decomposed before the minerals and nitrogen compounds can be brought to a condition in which they can either be taken up directly by the higher plants, or in which they can undergo other transformations due to the action of other groups of moulds or bacteria. It is stated that nearly all the simple and complex organic carbon compounds in the soil can be attacked by some group or other of moulds, which thus play an important part in soil fertility. The moulds attack the carbohydrates very readily, perhaps even more readily than the bacteria, and they cause rapid decomposition of these compounds. Although more information is necessary, it appears certain now that future theories of soil fertility will have to be constructed not only from the point of view of nitrogenous manures and fertilizers and nitrogen content of the soil, but also by taking into consideration the nature and amount of carbon compounds added to it.

It must be kept in mind, however, that lower plant organisms like moulds, when present in the soil, compete with the higher plants in utilizing nitrogenous compounds for their own growth. Thus the soil moulds may produce an unfavourable effect upon soil fertility. Although this cannot be denied, two factors may be mentioned as in some degree counterbalancing the possible injury to higher plants. First, an excess of ammonium salts or nitrates in the soil tends to large losses by leaching, especially under wet climatic

conditions, the utilization, therefore, of some of these salts by the soil moulds may serve usefully for the conservation of some of this nitrogen in the soil which would otherwise be lost. Secondly, the life processes of the moulds tend to the liberation of ammonia, and to the restoring again to the soil of the nitrogen assimilated by them in an available form. Thus moulds, from this point of view, may act in the soil as storing agents for soluble nitrogen compounds; and the possible injury caused by them in competing with the higher plants for the available nitrogen may be more than compensated for by their ability to store the nitrogen and make it afterwards slowly available for the plants.

Information up to the present leads to the belief that the mould flora is more active in acid than in neutral or alkaline soil, although it does not preclude the fact that moulds are developed also in the latter type of soil. It is possible that some of the soil moulds are active in the production of acids from available carbohydrates; thus soil acidity may be due in some part not only to the production of mineral acid owing to the oxidization of minerals or added fertilizers, but also to the production by soil moulds of organic acids, such as citric and oxalic. These acids may also act upon the insoluble phosphates and other minerals in the soil, and bring them into a soluble form available for the higher plants.

One other point with regard to moulds is worth noting. Plant pathologists know that a soil may become " sick " with respect to a particular crop, due to the fact that continuous cultivation of one crop on the same soil has caused that soil to become infested with large numbers of organisms pathogenic to that particular crop. Parasitic moulds of this type have, however, been isolated from virgin soils, or from soils on which the crop they parasitized has never been grown. Further investigations are needed as to how far the soil may be considered a possible medium for nourishing moulds likely to prove dangerously parasitic.

Notes

BOARD OF AGRICULTURE IN INDIA.

THE Eleventh Meeting of the Board will be held at Pusa from the 1st to the 6th December, 1919, when the following subjects will be discussed :—

I. Programmes of work of the Imperial Department of Agriculture and of the Director and First Bacteriologist, Muktesar.

II. Programmes of work of the Provincial Agricultural and Veterinary Departments and of Native States Departments of Agriculture.

III. The necessity for investigation into the conditions of nitrogen fixation in Indian soils.

IV. Whether there is any danger of reducing the level of fertility of Indian soils by the growing of high yielding varieties of crops and the adoption of intensive methods of cultivation, without, at the same time, providing an increased supply of manurial constituents. If so, how this danger can best be met.

V. The possibility of improving (*a*) forecasts, (*b*) final statistics of areas and yields of crops in India with special reference to the recommendations in Chapter XVII of the Cotton Committee's Report.

VI. Whether it would not be to the advantage of Indian agriculture that village *panchayats* should be empowered, where this has not already been done, to raise local rates and to initiate land acquisition proceedings for the

purpose of constructing and maintaining agricultural roads, drainage and irrigation works, and the improvement of scattered holdings, and that the necessity of creating village *panchayats* for these purposes, where they do not already exist, should be impressed upon Local Governments.

VII. Whether the Agricultural Department should not undertake the writing of books of the following types :—

(*a*) Story books idealizing agriculture and rural life generally ;

(*b*) Popular bulletins describing improved methods of agriculture ; and

(*c*) School Readers containing lessons on subjects pertaining to agriculture, in order to interest literate Indian cultivators in their life's work and to assist in the improvement of rural education.

VIII. In view of the fact that the poor acreage outturns obtained in India are to a considerable extent due to the use of inferior tillage implements, what steps, if any, should be taken to encourage the manufacture of improved implements in this country on a large scale.

IX. The importance of conserving such natural sources of manure as oilcakes, bones and fish for use in the country. What practical measures can be adopted to attain to this end ?

X. The preparation for famine conditions so far as the Agricultural Department is concerned. Can any steps be taken in advance to meet famine conditions which may occur in the future ? Can any measures be adopted to prevent good strains of crops going out of existence in famine years ?

XI. Whether any special measures are necessary with regard to the initiation or control of extensive experiments with agricultural power machinery, with special reference to motor ploughs and tractors.

XII. A complete review and discussion of the permanent experimental plots at Pusa which were laid down by a Committee of the Board of Agriculture in 1908.

XIII. Whether it is necessary to reconsider the recommendations made by the Board of Agriculture of 1916 that Government should not restrict the export of cattle that are in demand abroad.

XIV. The improvement of cotton marketing in India, with special reference to the recommendations of the Indian Cotton Committee, paragraph 233.

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WHEAT YIELDS IN THE UNITED PROVINCES.

THE season which has just passed has not been a very good one for wheat. Some of it was sown late and much depended on the absence of hot west winds during the growing period. Unfortunately, there were a few days of hot wind at the beginning of March which damaged the backward crop and took several maunds off the yield. In consequence of this the outturns at the farms of the Agricultural Department have on the whole not been high and are lower than those of the past two seasons. But in some cases very high yields have been obtained even in this year, and I propose to describe the method of cultivation followed so that others who read this Journal may be induced to try it. If they do, perhaps they will themselves write and describe their experiences.

The department have been endeavouring to introduce the sowing of cane in shallow trenches, as promising the best and most certain results with improved varieties, both as regards germination and yield and sugar. Under this system, a trench two feet wide and six inches deep is dug: the earth in the trench so made is then dug with "kasis" to a further depth of nine inches and the available manure applied. Though somewhat more expensive than sowing on the flat, yet later on it saves much labour and trouble in earthing up the crop. It is essential for thick varieties which will otherwise fall down in the monsoon and the value of the cane greatly deteriorate.

It had been noted in previous years that this method of cultivating the land had a surprising effect on the succeeding wheat crop. It was more marked than usual on this year's crop. The land so cultivated had retained, except where the rains completely failed, sufficient moisture for sowing without irrigation, though in the neighbouring fields a "palewa" had often to be given before sowing. Good cultivators in these provinces are fully aware of the advantages of sowing on moisture, and make every effort to retain it even in canal-irrigated tracts.

At the Shahjahanpur farm the wheat on land which had been trenched the year before stood out above the crops of the neighbouring fields, though they too had been sown on natural moisture and on cane land which had received the same amount of manure but had not been trenched. The yields were excellent. At the Bijauria farm, Bareilly District, there was a block of wheat on six acres of such land. Up to March it was the finest wheat I had seen in India, and the Superintendent of the farm was confident that the yield would be well over 40 maunds per acre. Unfortunately part of it fell down with the heavy winds in March, and rats damaged the fallen ears. When threshed the average was just under 37 maunds. At the Shahjahanpur farm, the average yield of 3½ acres was much about the same, *viz.*, 36 maunds. This land had received no manure other than which had been applied to the previous cane crop, and was at the ordinary rate given to cane. The first of these crops was irrigated once only, that at Shahjahanpur twice. It would seem from this that quite apart from the advantages to the cane, this system of trenching will pay for itself in the next wheat crop. The cost of the operation is about Rs. 15 per acre, and considering that a good crop of improved cane will yield produce worth Rs. 350 to Rs. 450 per acre and that wheat is now selling somewhere about Rs. 5 per maund, the outlay is not excessive and the system should be worth trial in those districts where cane and wheat are commonly grown in rotation. But some strong-strawed wheat like Pusa 12 must be sown, or the heavy crop will fall with any wind or rain.—[The Hon'ble MR. H. R. C. HAILEY, in the *United Provinces War Journal,* dated 15th May, 1919.]

CERTAIN ASPECTS OF THE ORGANIZATION AND POLICY OF THE AGRICULTURAL DEPARTMENT IN BENGAL.

A Resolution, dated 7th June, 1919, issued by the Government of Bengal, says :—

As it is desirable to place the public in possession of the intentions and policy of the Agricultural Department in the agricultural development of the Bengal Presidency, the Governor in Council deems it advisable to explain in some detail certain aspects of the organization of the department, together with some suggestions derived from the experience of other countries as to how the people can best benefit from its activities.

The necessity for private effort. The two main branches of the department are the research and demonstration branches. It is, however, clear that the activities of the department in respect of the demonstration of the results of the investigations of the research branch cannot be expected to reach more than a fringe of the agricultural population without the help of the public. On the one hand, the extent of such activities is conditioned by financial considerations; on the other hand, any development of the kind is of no avail if the people are not ready or cannot arrange to take advantage of it. Individually the agriculturist is ready; experience in this country has shown that if he can see with his own eyes the value of an improvement he will adopt it. But if all are to benefit, experience in other countries shows that the agriculturists must meet Government half-way in the matter. It has been found in those countries that, if small associations of agriculturists are formed to test and adjudicate on suggested improvements, to discuss their successes and failures with each other, and to bring their needs to the notice of the Agricultural Department, then not only is the practical problem of how to reach the whole agricultural population solved, but there is hardly any limit to advancement in the direction of improved production, economic distribution, improvement of breed, and indeed in all mental and moral development. In the words of an American Professor of Political Economy, Dr. J. A. Ryan, "The transformation in the rural life of more than one European

community through co-operation has amounted to little less than a revolution. Higher standards of agricultural products and production have been set up and maintained, better methods of farming have been inculcated and enforced, and the whole social, moral and civil life of the people has been raised to a higher level. From the view-point of material gain, the chief benefits of agricultural co-operation have been the elimination of unnecessary middlemen, and the economies of buying in large quantities, and selling in the best markets, and employing the most efficient implements."

An essential condition, however, for the success of such associations is that they should be conducted on the basis of self-help. It is desirable for Government to assist such associations by teaching and exercising close control; but interference with their management or the grant of pecuniary aid by Government impairs the fundamental principle of self-reliance.

Formation of small agricultural associations in Bengal. What precise form private effort should take in Bengal, it is perhaps too early to prophesy. But undoubtedly there is every reason to believe, from the experience gained in other countries, that the formation of small agricultural associations should prove successful, whether as simple associations formed for the purpose mentioned in the preceding paragraph, or as co-operative societies dealing with the purchase of seeds and implements or with the distribution of agricultural produce. There is probably room for associations combining one or more of these functions. Apart from foreign experience and experience in other provinces in India, there is also the definite fact that such simple associations, serving thanas or even smaller areas, have met with marked success in the district of Birbhum in the Bengal Presidency. By the co-operation of official organization and private effort of this nature not only will the successes obtained by experiment be brought to fruition in the interior, but Government will be furnished with a first-hand agency for ascertaining the real needs and the wishes of the agricultural population.

His Excellency in Council hopes, therefore, to see a further extension of this experiment throughout the province, particularly

in those districts in which demonstration farms already exist or are about to be established, as it is in those districts that the Agricultural Department can give the most help. The formation of such associations rests, however, with the public; and they will only be successful if they are financed and managed by the people. The principle accepted as essential by the Board of Agriculture in India, at their seventh meeting in 1911, was that those who are associated should all be agriculturists, really interested in local agricultural improvement.

The officers of the Departments of Agriculture and Co-operative Societies will be ready at all times with their advice and counsel.

Functions of existing associations. The extension of such small associations, if carried into effect, will inevitably involve some alteration in the functions of the existing provincial, district and divisional agricultural associations. The district associations may, for example, find, as time goes on, that their executive functions are being gradually absorbed by the working village societies. For the present, they may find that their duties are devoted to the organization of such societies. The development will of necessity be a gradual process, and the present associations will doubtless adapt themselves to changing circumstances or give way to a different organization if they cease to satisfy a real need.

The divisional associations, in particular, may not be required, while experience may show that the functions at present discharged by the provincial association can be more effectively performed by the new Board of the Agricultural Department which has been created.

Establishment of demonstration and seed farms. The research work of the department, or, more properly speaking, the investigation work, is mainly conducted at the Dacca Agricultural Station, which is the headquarters of the chemical, botanical and fibre sections, while there is a smaller investigating centre in West Bengal at Chinsura. At these centres problems of practical utility to Bengal agriculturists are investigated, such as the production of improved rice, jute and sugarcane, the suitability of various fertilizers, the

prevention of insect pests and so on; and not, as there is a tendency in some quarters to believe, research work of a purely academic interest. For the purpose of testing the results obtained at these research stations and demonstrating their value, smaller stations or farms have been established at Rajshahi and Rangpur. Private farms at Burdwan and Kalimpong are also managed by the department. The utility of these stations has been fully proved and the necessity for small farms in every district accentuated, owing to the success attained in the plant-breeding sections of the department. It has thus become necessary to arrange for the establishment of a demonstration and seed farm in each district, for the dual purpose of adjusting the results of scientific investigations at the central research stations to local conditions and of taking up the study of purely local problems. Each farm will form a centre for the demonstration of such items as have been found by actual tests to be suited to local conditions. A programme is, therefore, under contemplation for gradually providing every district in Bengal with a demonstration and seed farm as soon as practicable, whilst official sanction has already been accorded to the establishment of such farms at Mymensingh, Bogra and Comilla.

Co-operation of District Boards in establishment of farms. In view of the popular interest in agriculture, it has also been considered desirable to enlist the interest of the District Boards by requesting them to co-operate in the establishment, maintenance and management of the farms, subject to the professional control of the Agricultural Department.

In the view of His Excellency in Council the forms which the assistance from District Boards may legitimately take are as follows :—

(1) Provision of land or of money towards the acquisition of the land or towards the necessary buildings.

(2) Provision for the whole or a portion of the recurring expenditure on a farm.

The Governor in Council holds that District Boards should possess a voice in the management of the farms to the extent to which they contribute, subject to the professional control of the

department. Certain District Boards have already agreed to co-operate on these lines.

Demonstrators. For the purpose of advertising the results obtained at the central research stations and on these farms and in advising the small agricultural associations which are expected to come into being, definite circles, such as the area of a police station, are necessary for demonstration work in charge of demonstrators working under the supervision of agricultural officers. Twenty-six district agricultural officers, *i.e.*, one for each district in the presidency, have now been sanctioned ; five additional agricultural officers have also been appointed for special work ; and there are at present altogether 79 demonstrators. It is contemplated that, with the completion of the programme for the construction of farms and the multiplication of small agricultural associations, the number of these demonstrators will be gradually but largely increased, until there is one for each police station in Bengal.

Seed-stores. Experience in Bengal has shown that the immediate result of successful demonstration at any of the farms already in existence is a demand for improved agricultural appliances, and for seed of a new crop or of a new variety of crop. In fact, agricultural improvement in India necessitates in nearly every case the use of some new thing. whether it be seeds, fertilizers, implements or insecticides. This is exemplified by the insistent and growing demand for seed-stores in those districts where seed of a new crop variety has been issued. One seed-store will not be sufficient in a district ; but seed-stores should be established also at every subdivisional headquarters and at all demonstration centres. To produce the best results such seed-stores should, however, be established and maintained by such bodies as agricultural associations or co-operative societies or local authorities. It is not, therefore, the policy of Government to establish and maintain such seed-stores themselves for areas smaller than a subdivision. Not only would this involve too large a commercial undertaking for a Government—where attempted in other countries, it has ultimately been abandoned for this reason—but it would involve too great an encroachment on the sphere of private effort. There are already

30 stores in existence under the auspices of Government, and 71 are being created under local organizations.

General policy. By the continuance of investigation for practical ends at the central farms, by the creation of demonstration farms in every district and seed-stores in every subdivision, by the appointment of a staff of agricultural officers and demonstrators in sufficient numbers to aid district officers and the department on the one hand, and the agriculturists, either individually or in association, on the other, the Bengal Government are aiming at the solution of the two problems which the Agricultural Adviser to the Government of India has declared to dominate the whole situation : the first is the provision of the best obtainable seed for any type of agricultural produce, and the second the creation of an agency for its distribution.

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THE following further extracts from official reports dealing with the use of **cactus** in the Ahmednagar District **as a fodder substitute** have been published by the Bombay Government : —

Extract from a Report No. B.—854—1918, *dated* 29*th May,* 1919, *from the Honourable Mr. L. J. Mountford, C.B.E., I.C.S., Commissioner, Central Division.*

After touring through parts of four tálukas of the Ahmednagar District and inspecting cattle camps and villages where cattle are fed on cactus, I am of opinion that the villagers have a very valuable fodder adjunct for their *kadbi* (*Sorghum* stalks) in cactus properly prepared, and consider it would be well if our expert veterinary officers could give a definite opinion on this point.

The preparation is simple. It consists in roasting the cactus over a village forge and chopping it up fine. The thorns catch fire readily, and with very little care all thorns can be destroyed. In some places women also extracted the charred tufts. This is not considered necessary, but it probably assists digestion. An admixture of strengthening food is advisable where *kadbi* is not available. In Ahmednagar, they add two pounds of cotton seed and occasionally one pound *chuni* (gram and lentil husks) to the 24 pounds full feed.

In the camps and kitchens I visited, I found cattle eating the stuff greedily. Some cattle and buffaloes will eat the prepared leaves whole, but chopped fodder is best. The people are quite enthusiastic, and, from reports received, some villages have taken to this fodder almost in a body, such as Brahmanwada (Akola) and Pedgaon (Shrigonda) and many others.

Cactus operations are not new to Ahmednagar, as they were carried out in 1912; but the village busy-body was not absent. Various rumours were started which at first somewhat impeded the campaign, such as that compulsory payment would be insisted on when the cactus campaign was closed; that the animals would die, and, when it was found that animals did not die, that they would die off in the rains. This prophecy still obtains among cactus opponents.

Villagers visit the camps and kitchens with their cattle, or ask to be allowed to take some rations away to their villages; where possible, choppers, bellows and prongs are given them. Many come to Mr. Beyts's bungalow for instruction, and while I was there, two very fine cattle in splendid condition were brought by their owner to be taught to eat cactus. I have seen cattle brought in by their owners eat their ration for the first time straightaway.

Cattle which had not the strength to raise themselves from the ground two months ago in some of the camps, are now able to do light work at the *mhote*, and to pull the cactus carts. Mr. Beyts purchased many miserable animals in the last stage of exhaustion from the butchers for a few rupees, and, after feeding them on cactus preparation, has sold them to the ryots for three times the purchase money. Mortality was very heavy before the cactus campaign started. One owner told me he lost seven of his cattle that he had fed on grass purchased for Rs. 2,000; and that he had lost none since he took to cactus. The mortality in the cactus camps has been slight.

At present there are over 34,000 cattle feeding on cactus, and it would have been utterly impossible to find grass or *kadbi* to feed these cattle. They would require at eight pounds of grass or *kadbi* a day (a low all-over daily average for cattle and young stock) some

272,000 pounds or over 80 lakhs per month. This amount of grass could not be obtained.

The present price of *kadbi* in the market varies from Rs. 40 to Rs. 60 per 1,000 pounds, while the cost of 1,000 pounds of cactus, cleaned, chopped and prepared for food is Rs. 2, to which is added Rs. 5 worth of cotton seed which is very expensive at present. *Chuni* is often added where procurable, but is not essential.

Cactus no doubt possesses a certain feeding value, but is most useful when used with cotton seed. It can also be mixed with chopped *kadbi* in the proportion of 2 to 1, and if, as is hoped, the ryots will recognize what a valuable green fodder they have all around them, the fodder resources of the country will be vastly increased, and future famines will be robbed of much of their terrors. In 1912 cattle preferred prepared cactus to the famine grass that was available that year.

I visited a charitable grass camp at Ahmednagar and elsewhere, and found the animals in no better condition than in the cactus camps. Where, as happened in both classes of camps, animals came in a very poor condition, mortality was to be expected. In one grass camp the mortality was 20 per cent. and there were many animals on the sick list, and I understand the mortality in the cactus camps did not approach this figure. I came to the conclusion that dry grass alone is not sufficient for famine cattle. In the first place, really good grass of sufficient nutriment is difficult to procure; and, secondly, some green stuff is necessary. Cattle appear to thrive better on cactus with the adjuncts employed in Ahmednagar. Again, foreign grass often disagrees with cattle. Although the local cattle in the Dángs thrive on grass, there were very heavy losses among the Ahmednagar cattle sent there, and those that returned came back in a miserable condition.

Extract from a Report No. 1996, *dated* 11*th June*, 1919, *from Lieutenant-Colonel G. K. Walker, C.I.E., O.B.E., F.R.C.V.S., Superintendent, Civil Veterinary Department, Bombay Presidency.*

I have visited cattle camps in the Ahmednagar and Poona Districts where cattle are being fed on prickly pear, and recently

(May 11th to 15th) I made a detailed inspection in the Ahmednagar District in this connection. I paid surprise visits to a number of villages in various directions where the fodder was being used, and visited the camps at Ráhuri, Shrigonda and Wakodi. I also visited the charitable camp at Ahmednagar where the cattle were being fed on dried grass and *kadbi*, no prickly pear being used.

I can bear out the Hon. Mr. Mountford's statements in every particular. There can be no doubt that cattle can be maintained on prickly pear when necessary without harm. It is not claimed that it ranks as a good fodder, and it should be supplemented with a certain amount of dried grass if possible in addition to some proportion of concentrate. Cattle require a proportion of green fodder to keep in good health, and the dried grass that passes as hay in this country is frequently so inferior and innutritious that it causes internal disorders, especially in debilitated cattle. Animals have their idiosyncrasies, and there may be cases where prickly pear causes indigestion, especially if it is improperly prepared. It is essential that all the prickles should be removed. Like all green fodders it produces some looseness of the bowels, which is considered normal to cattle in countries where green fodder is common. Any excessive looseness can be remedied usually by supplying fodder in intelligent proportions. Diarrhœa in cattle in the rains is common from various causes. I have written a leaflet on the subject, which is being published by the Agricultural Department in English and three vernaculars.

I beg to say that in my opinion the cactus fodder campaign, particularly in the Ahmednagar District, has been a great success, and that by the aid of this fodder a very large number of cattle that would otherwise have died have been saved. The work in the Poona District has also been effectual. A very pleasing feature in the Ahmednagar District is the obvious satisfaction of the cattle-owners when once they have been persuaded to take up the method. They have learned to appreciate its advantages, and in many places their own arrangements are well devised and working well.

IN the *Rhodesia Agricultural Journal*, December 1918, there is some advice as to plants suitable for forming **cattle-proof hedges** on Rhodesia. Among these is Bougainvillæa, especially the two species *glabra* and *spectabilis*. This is used as an ornamental hedge in some of the West Indian islands, and is certainly of a strong enough growth to form a close hedge of any height or width which may be desired. The blaze of colour in the flowering season, which is almost the whole year, makes it a most showy object. The two species of Bougainvillæa mentioned above grow easily from cuttings inserted in the ground. Until growth starts, they should be kept well supplied with water. The plants are extremely hardy, and when established, will stand long periods of drought.

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THE Rothamsted Experimental Station has been engaged for some time in field trials and other investigations to discover what value **ammonium nitrate** possessed as a **fertilizer**. Dr. E. J. Russell thus summarizes the general results of the experiments in the *Journal of the Board of Agriculture*, Vol. XXV, No. 11 :—

(1) Ammonium nitrate is an excellent fertilizer, the nitrogen of which is worth as much as that in nitrate of soda and sulphate of ammonia. At present prices of these two fertilizers, ammonium nitrate would, on the same basis, be worth £37 5*s*. per ton.

(2) It contains more than twice as much nitrogen as nitrate of soda, and one and three-quarters times as much as sulphate of ammonia : it is thus the most concentrated nitrogen fertilizer obtainable on the large scale. Where 1 cwt. of nitrate of soda or ¾ cwt. of sulphate of ammonia is ordinarily used, less than ½ cwt. of nitrate of ammonia would be required.

(3) It can be applied to any crop for which nitrate of soda is suitable, but it is not superior to sulphate of ammonia for potatoes, and may be inferior. Its proper use is as a top-dressing, and not as a constituent in mixed manures.

(4) Farmers must insist on having the "non-deliquescent" variety, otherwise they will certainly be inviting trouble.

(5) While the material itself is not inflammable, it yet helps a fire considerably. Great care is, therefore, necessary not to store under conditions where a fire might be started.

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THE COCOA PRODUCTION OF THE EMPIRE.

Among the products of the Empire which before the war were not utilized in the United Kingdom to the extent they might have been, cocoa takes a prominent place. The quantity of cocoa produced in British countries in 1913 was more than three times the amount consumed in the United Kingdom, yet that country only obtained about one-half its supplies from those sources, the remainder consisting largely of South American cocoa and foreign cocoa shipped *viâ* continental countries. Not only was this the case, but the British Isles were importing large quantities of prepared cocoa and chocolate from foreign countries which had been manufactured there from British grown cocoa. During the war the position improved and a much larger proportion of the raw cocoa came from the Empire, no less than 86 per cent. of the total imports coming from British possessions in 1917, and it is to be hoped that this state of affairs will continue. The importance of the matter will be realized when it is stated that in 1916 the total imports were valued at no less than six and three quarter million pounds sterling. The question of the production of cocoa in the different countries of the Empire, the world's consumption, and the cocoa trade of the United Kingdom is fully discussed in an article in the January–March (1919) Number of the "Bulletin of the Imperial Institute." Of the many interesting points brought out, two call for special mention. The first is the unprecedented growth of the cocoa industry in the Gold Coast, where the product is grown and prepared for the market entirely by the natives. The colony commenced to export cocoa in 1891 and it now produces more than one-quarter of the world's output. The other equally remarkable fact is the enormous increase in the consumption of cocoa in the United States in recent years. The consumption has trebled since 1913 and about one-half the total quantity produced in the world now goes to the States.

The cocoa industry of the Gold Coast is also dealt with at length in a message addressed to the Legislative Council of the Colony by Sir Hugh Clifford, the Governor, which appears in the same Number of the Bulletin.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

WOODHOUSE-SOUTHERN MEMORIAL FUND.

	Rs.
DONATIONS received up to the 31st May, 1919, and acknowledged in the *Agricultural Journal of India*, Vol. XIV, Pt. IV, July 1919	1,930
Donations received during the period from 1st June to 31st August, 1919 :—	
V. G. Gokhale, Esq.	10
S. K. Basu, Esq.	10
TOTAL ..	Rs. 1,950

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THE names of the undermentioned have been brought to the notice of the Government of India for valuable services rendered in India in connection with the war up to 31st December, 1918 :—

The Hon'ble Mr. H. R. C. Hailey, C.I.E., I.C.S., Director of Land Records and Agriculture, United Provinces.

Mr. B. C. Burt, M.B.E., B.Sc., Deputy Director of Agriculture, Cawnpore.

Colonel J. Farmer, C.I.E., F.R.C.V.S., Chief Superintendent, Civil Veterinary Department, Punjab.

Colonel H. T. Pease, C.I.E., M.R.C.V.S., Principal, Veterinary College, Punjab.

Mr. J. G. Cattell, M.R.C.V.S., Superintendent, Civil Veterinary Department, Sind, Baluchistan and Rajputana.

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LIEUT. (TEMP. COL.) GEOFFERY EVANS has been appointed an additional Companion of the Most Eminent Order of the Indian Empire in connection with the military operations in Mesopotamia.

MR. P. P. M. C. PLOWDEN, I.C.S., Joint Magistrate, Agra, has been appointed Under Secretary to the Government of India, Revenue and Agriculture Department.

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MR. W. A. DAVIS, B.Sc., A.C.G.I., has been granted special privilege leave for five months with effect from the 11th October, 1919.

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MR. G. S. HENDERSON, N.D.A., N.D.D., Imperial Agriculturist, has, on the termination of his deputation under the Munitions Board, been granted with effect from 23rd June, 1919, combined leave for six months, *viz.*, privilege leave for 3 months and 10 days and study leave for the remaining period.

***

MR. J. H. WALTON, B.A., B.Sc., Supernumerary Agricultural Bacteriologist, Pusa, has been granted combined leave for six months.

***

THE services of Mr. M. Afzal Husain, B.A., Supernumerary Entomologist, Pusa, have been placed at the disposal of the Government of the Punjab.

***

MR. J. F. DASTUR, M.Sc., who has been appointed to the Indian Agricultural Service, is appointed Supernumerary Mycologist at Pusa, with effect from the 30th June, 1919, and deputed to England for fifteen months for training.

***

MR. W. A. POOL, M.R.C.V.S., on reversion from military service, has been appointed Second Bacteriologist, Imperial Bacteriological Laboratory, Muktesar, with effect from the 30th July, 1919.

MR. G. A. D. STUART, I.C.S., is granted combined leave for one year with effect from the date of relief of his officiating appointment as Agricultural Adviser to the Government of India.

***

MR. R. H. ELLIS, I.C.S., has been appointed to act as Director of Agriculture, Madras, in relief of Mr. R. Cecil Wood, M.A., and until further orders.

***

MR. R. C. BROADFOOT, Probationary Deputy Director of Agriculture, Madras, has been appointed to act as Superintendent, Central Farm, Coimbatore.

***

MR. P. H. RAMA REDDI, Probationary Deputy Director of Agriculture, Madras, has been appointed on completion of his training to act as Deputy Director, II & III Circles, *vice* Mr. G. R. Hilson granted leave or until further orders.

***

MR. P. C. PATIL, L.AG., who has been appointed to the Indian Agricultural Service, has been confirmed in the appointment of Deputy Director of Agriculture, Northern Division, Bombay, from the 1st March, 1919.

***

MR. BHIMBHAI M. DESAI has been appointed Deputy Director of Agriculture, Gujarat, with effect from the 1st April, 1919.

***

MR. D. L. SAHASRABUDHE, B.SC., L.AG., Assistant Professor of Chemistry at the Agricultural College, Poona, has been appointed to act as Agricultural Chemist to Government, Bombay, with effect from the 1st June, 1919, pending further orders.

***

MR. G. TAYLOR, M.R.C.V.S., Superintendent, Civil Veterinary Department, South Punjab, has been appointed to officiate as

Superintendent, Civil Veterinary Department, Bombay, with effect from the 12th July, 1919, *vice* Lieutenant-Colonel G. K. Walker, C.I.E., O.B.E., F.R.C.V.S., appointed to officiate as Principal, Veterinary College, Lahore.

***

MR. A. D. McGREGOR has been appointed to act as Superintendent, Civil Veterinary Department, Bengal.

***

MR. RAJESWAR DAS GUPTA, who has been appointed to the Indian Agricultural Service, has been confirmed as Deputy Director of Agriculture, Bengal, from the 1st April, 1919. He has been placed in charge of the Northern Circle, but will continue to act as Deputy Director of Agriculture, Western Circle, in addition to his own duties, during the absence of Mr. F. Smith on leave.

***

MR. N. S. McGOWAN, B.A., Professor of Agriculture, Agricultural College, Sabour, has been granted combined leave for one year from the 1st April, 1919. Mr. Surendranath Sil, B.A., M.Sc. A., officiates as Professor of Agriculture during Mr. McGowan's absence.

***

MR. T. F. QUIRKE, M.R.C.V.S., Superintendent, Civil Veterinary Department, North Punjab and North-West Frontier Province, has been granted combined leave for six months with effect from 26th May, 1919. Mr. J. S. Garewal, M.R.C.V.S., officiates in Mr. Quirke's place.

***

RAI SAHIB LALA KOTU RAM, Deputy Superintendent, Civil Veterinary Department, has been appointed to act as Superintendent, Civil Veterinary Department, South Punjab, *vice* Mr. G. Taylor transferred to Bombay.

***

MR. H. E. CROSS, M.R.C.V.S., Civil Veterinary Department, Punjab, has been granted an extension of furlough for eight months.

Mr. F. J. Plymen, A.C.G.I., Deputy Director of Agriculture, has resigned his seat on the Legislative Council of the Chief Commissioner of the Central Provinces.

*
* *

Mr. G. Evans, C.I.E., M.A., on the completion of his special duty in Burma, has returned to the Central Provinces.

*
* *

Mr. A. G. Birt, B.Sc., Deputy Director of Agriculture, Assam, is allowed combined leave for one year and four months with effect from the 24th June, 1919. Srijut Lakheswar Barthakur, Superintendent of Agriculture, Assam Valley, is appointed to officiate.

*
* *

Mr. E. S. Farbrother, M.R.C.V.S., is confirmed in the Civil Veterinary Department and appointed to officiate as Superintendent, Civil Veterinary Department, Sind, Baluchistan and Rajputana, with effect from the 1st July, 1919.

*
* *

The seventh annual meeting of the Indian Science Congress will be held at Nagpur from the 12th to the 17th January, 1920.

Sir Benjamin Robertson, K.C.S.I., K.C.M.G., C.I.E., Chief Commissioner of the Central Provinces, has consented to be Patron of the meeting, whilst Sir P. C. Ray, C.I.E., D.Sc., Ph.D., Palit Professor of Chemistry, Calcutta University, will be its President.

The Sectional Presidents will be :—

Applied Botany and Agriculture. Mr. D. Clouston, C.I.E., M.A., B.Sc., Offg. Director of Agriculture, Central Provinces.

Physics and Mathematics. Dr. N. A. F. Moos, F.R.S.E., formerly Director, Bombay and Alibag Observatories.

Chemistry. Mr. B. K. Singh, M.A., F.C.S., Offg. Professor of Chemistry, Government College, Lahore.

Systematic Botany. Mr. P. F. Fyson, B.A., F.L.S., Professor of Botany, Presidency College, Madras.

Zoology. Mr. E. Vredenburg, B.L., B.Sc., A.R.S.M., A.R.C.S., F.G.S., Superintendent, Geological Survey of India.

Geology. Mr. P. Sampatiengar, M.A., F.G.S., Offg. Geologist, Department of Geology and Mines, Mysore.

Medical Research. Lieut.-Col. J. W. Cornwall, M.A., M.D., D.P.H., I.M.S., Director, Southern India Pasteur Institute, Coonoor.

Further particulars of the meeting may be obtained from the Honorary Secretary, Dr. J. L. Simonsen, Forest Research Institute, Dehra Dun.

Reviews

Forecasting the Yield and the Price of Cotton.—By H. L. MOORE. (Macmillan & Co.)

THE United States produces more than one-half of the total world's output of cotton of 30 million bales, but, owing to the organization of the American trade, the price of cotton in every market in the world depends more on the American price than the relative American production alone would indicate. The prediction of the yield and price of American cotton is, therefore, a matter which concerns the whole cotton-buying world. In applying the method of correlation to the problem of the yield of American cotton Professor Moore has been anticipated by Kincer. But Kincer, though he obtained a high value for the correlation, did so by multiplying his rain and temperature variables by more or less arbitrary coefficients, which themselves depend on the antecedent climatic conditions. By choosing a sufficient number of such coefficients any correlation however high can be obtained, and there is no assurance that the formula of prediction is anything more than an empiricism, summing up past events, but of no use in predicting future ones. To this criticism the whole theory of correlation, except where it is used to measure quantitatively the association between known 'veræ causæ,' and their effect is, to some extent, exposed. In using the method of multiple correlation, in particular, long series are necessary if the number of variables used is at all large. Thus Professor Moore uses the rainfall in May, and the mean temperatures of June and August to predict the yield of cotton in Georgia, and obtains a multiple correlation coefficient of 0·732, which suffices to cut down the error of prediction to about 70 per cent. of the error of a pure guess based on the mean outturn. But the series from which the 3 total correlations are obtained is only one of 20 years,

and this somewhat modifies, though it does not entirely vitiate, the value of the formula of prediction. The results obtained for Georgia suggest that high rainfall in May and high temperature in August are harmful to the cotton crop, while in June high temperatures are beneficial. To what extent these are true effects of rainfall and temperature, or merely the result of some allied condition, such as plant disease, which in its turn is dependent on climate, cannot of course be stated off-hand, nor indeed, for a first approximation forecast, does it matter. For the prediction of the price of Upland cotton from the total American output in bales, even higher correlations are obtained. For example, the correlation between the percentage change in price and the percentage in production is found to be $-0{\cdot}819$ and the multiple correlation co-efficient between the price of Upland cotton and the combined factors of total production of cotton and index prices of all commodities is $0{\cdot}859$, from which the error of prediction can be reduced to one-half of the standard deviation of the price of cotton from year to year. It appears, however, to be nowhere stated on what date the price is taken.

Though Professor Moore has obtained some useful results, and has shown conclusively that from climatic conditions the American cotton crop can be forecasted in nearly every case more accurately than the official forecast succeeds in doing, and that often a month earlier, it is impossible to admit that he has obtained a complete solution of the problem of cotton prices, or indeed that such a solution can be found from the mere application of the method of multiple correlation, as Professor Moore appears to imagine (p. 151). That an immense improvement in official crop forecasts can be effected by the method of correlation has been known in India for many years, and it has been shown that some sugarcane forecasts are, like the May American cotton forecasts, worse than useless; but to suppose that a final physical, chemical, physiological and economic phenomenon solution is to be obtained by pure statistics is a misconception, which nevertheless should not blind us to the merits of the methods evolved by Francis Galton and Karl Pearson.

In another respect Professor Moore seems to go above his last in attempting to better the official forecast of cotton based on the

condition-ratio figures issued on the 1st of May, June, July and August. These figures Professor Moore correlates with the corresponding yield-ratios, and finds as was to be expected that the correlation is less than unity. He then constructs the regression equation of yield-ratio on condition-ratio, and offers this as a better prediction formula than the official prediction itself. This is an astonishing perversion of the method of statistics. Fortunately the author only seems to treat this prediction formula as a side issue, but as it has no meaning whatever it should not have been introduced.

To sum up, the book is a definite step on the lines of attack of the problem of forecasts adopted by Hooker, Warren Smith and others. [S. M. J.]

***

Farmers' Clean Milk Book—By CHARLES EDWARD NORTH, M.D. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall.) Price 5*s*. net.

THIS book is got up on the popular style. The matter is expressed in non-technical language and will appeal to a very wide circle of readers. Although the advice is useful, nothing fresh is given to dairymen who carry on their work in an up-to-date manner. It may naturally be inferred from the publication of a work of this kind that the health authorities think that there is still much headway to make in producing safe milk in America.

While some information regarding the entry of the disease-producing bacteria into milk is given, and while pasteurization is described in a general way, an important point, namely, the thermal death-point of disease-producing germs and the exposure required at a given temperature to kill them, is omitted. In other words, the temperature of pasteurization and the time for which milk should be kept at that given temperature under different conditions have been passed over. Since the ordinary conditions of practical dairying differ considerably from those in the laboratory, Dr. North might have instructed his readers on points regarding temperature and exposure required to kill the more important pathogenic bacteria.

The importance of the personal element, namely, persons working with milk being cleanly as regards themselves, and also as regards cows and dairy utensils, is a point with which all will agree. Dr. North has demonstrated this by arranging for good dairymen to take over temporarily inefficient dairies and manage such in an up-to-date manner. The results obtained are very striking indeed, and one is surprised that there should be still in America such backward methods in practice.

Apparently in America most milk producers object to the frequent visits of the dairy inspectors, as they add to the cost of producing milk. Such things as up-to-date management of cattle, buildings, pasteurizing, etc., etc., all cost money, and add very considerably to the cost of production. It is here that the health authorities, the producers and the consumers appear to come into conflict. The consumer wants cheap milk, the health authorities demand that milk should be produced on up-to-date lines, thereby adding to the cost of production; while the milk producers insist that the increased rates paid for an up-to-date milk supply are not commensurate with the increased expenditure.

While the book aims at educating the milk producers and dairymen, little has been demonstrated on the lines of educating public opinion on the value of a satisfactory milk supply. Some hints to milk consumers generally would also have proved useful and added to the value of the work.

In the closing chapter, dairy arithmetic is dealt with, and it is there shown that, taking the food item alone, good milking cows produce milk at a lower cost than bad milking cows. The statement, while correct, is very incomplete, as at least 13 other items add their quota to the cost of milk production. Such statements are liable to create in the mind of consumers some suspicions as regards farmers' profits. In cases of this kind, one should like to see the subject of costs either fully dealt with or entirely omitted.

On the whole, the book contains useful information and may be read with advantage. [A. C.]

Correspondence

INTERMITTENT BEARING OF FRUIT TREES.

To The Editor,

The Agricultural Journal of India.

Sir,

In a note published on page 673, Vol. XIV, Part IV, of your journal, and entitled "How to avoid intermittent bearing of fruit trees," there appears a review of an article from "Country Life." The author of the article attributes the non-bearing of certain fruit trees in alternate years to the exhaustion of all reserve material during the years of abundant bearing. He considers that this may be rectified by a liberal supply of easily assimilable manure at the time of the formation of fruit buds for the coming year. In support of this suggestion he cites the regular bearing of espalier trees and trees under glass.

Readers of your valuable journal may be interested to know that the same question with reference to apple trees, is discussed in an illustrated article in the "Journal of Heredity," Vol. IX, No. 7, November 1918. The author, Mr. B. S. Brown, considers this biennial bearing condition to be a "habit" forced on the tree by conditions of environment in the early life-history of the individual. This habit is said to be not inheritable and can largely be corrected by a copious thinning of the fruits during the bearing year to prevent complete exhaustion. There is an interesting illustration of a graft apple tree, half "Gravenstein" and half "Russian," in which the two halves, for some unaccountable reason, have chosen two opposite years for their heavy crop, with the result that in one year one half is loaded with fruits and in the succeeding year the other half.

Yours faithfully,

T. S. Venkataraman,

Ag. Govt. Sugarcane Expert.

Coimbatore

The 18*th July,* 1919.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. Lawson's Text-Book of Botany (Indian edition). Revised and adapted by Birbal Sahni and M. Willis. With a preface by Dr. J. C. Willis. New and revised edition. Pp. xii+610. (London : W. B. Clive, University Tutorial Press.) Price, 8*s*. 6*d*.
2. Botany of the Living Plant, by F. O. Bower. Pp. x+580. (London : Macmillan & Co.) Price, 25*s*. net.
3. The Strawberry in North America—History, Origin, Botany, and Breeding, by Professor S. W. Fletcher. Pp. xiv+234. (London : Macmillan & Co.) Price, 8*s*. net.
4. Practical Physiological Chemistry, by S. W. Cole. With an introduction by Professor F. G. Hopkins. Fifth edition. Pp. xvi+401. (Cambridge : W. Heffer & Sons, Ltd.; London : Simpkin, Marshall, Ltd.) Price, 15*s*. net.
5. Productive Agriculture, by Professor J. H. Gehres. Pp. xii+436. (London : Macmillan & Co.) Price, 5*s*. 6*d*. net.
6. Irrigation Engineering, by Dr. A. P. Davis and H. M. Wilson. Seventh edition. Pp. xxiii+640. (New York : J. Wiley & Sons, Inc.; London : Chapman & Hall.) Price, 21*s*. net.
7. Practical Butter-making, by C. W. Walker-Tisdale and T. R. Robinson. Fourth revision. Pp. 143. (London : Headley Bros.) Price, 5*s*. 6*d*. net.
8. The Preparation of Substances important in Agriculture, by Prof. C. A. Peters. Third edition. Pp. vii+81. (New York : J. Wiley & Sons, Inc.; London : Chapman & Hall.) Price, 4*s*. net.

9. An Introduction to the Study of Biological Chemistry, by S. B. Schryver, D.Sc. Modern Outlook Series. Pp. 340. (London : J. C. and E. C. Jack.) Price, 6*s*. net.

10. Co-operation in Danish Agriculture, by Harold Faber, an English adaptation of *Andelsbevaegelsen i Denmark,* by H. Hartel, with a foreword by E. J. Russell. Pp. xxii+176. (London : Longmans Green & Co.) Price, 8*s*. 6*d*. net.

11. The Modern Milk Problem in Sanitation, Economics, and Agriculture, by J. S. MacNutt. Pp. xi+258+xvi plates. (London : Macmillan & Co.) Price, 10*s*. 6*d*. net.

12. Peach-growing, by H. P. Gould. Pp. xxi+426+xxxii plates. (London : Macmillan & Co.) Price, 10*s*. 6*d*. net.

13. Elementary Chemistry of Agriculture, by S. A. Woodhead. Pp. 188. (London : Macmillan & Co.)

14. Hints to Farm Pupils, by E. W. Lloyd. Pp. 112. (London : John Murray.) Price, 2*s*. 6*d*. net.

15. Co-operation for Farmers, by L. Smith Gordon. Pp. 247. (London : Williams & Norgate.) Price, 6*s*. net.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. Studies in Indian Sugarcanes, No. 4. Tillering or underground branching, by C. A. Barber, C.I.E., Sc.D., F.L.S. (Botanical Series, Vol. X, No. 2.) Price, Rs. 4-4 or 7*s*.

2. Studies in Indian Sugarcanes, No. 5. On testing the suitability of sugarcane varieties for different localities, by a system of measurements. Periodicity in the growth of the sugarcane, by C. A. Barber, C.I.E., Sc.D. F.L.S. (Botanical Series, Vol. X, No. 3.) Price, R. 1-12 or 3*s*.

3. The Phosphate Requirements of some Lower Burma Paddy Soils, by F. J. Warth, M.Sc., B.Sc.; and Maung Po Shin. (Chemical Series, Vol. V, No. 5.) Price, R. 1-12 or 3*s*. 3*d*

Bulletins.

1. Cawnpore-American Cotton : An Account of Experiments in its Improvement by Pure Line Selection and of Field Trials, 1913–1917, by B. C. Burt, B.Sc., and Nizamuddin Haider. (Bulletin No. 88.) Price, As. 10 or 1*s*.
2. Resham-shilper unnatikalpé tuntbhook resham keetjáti sambandhe parikshar dwitiya bibaranee, by M. N. De. (Bengalee version of Pusa Bulletin No. 74 on "Second Report on the Experiments carried out at Pusa to Improve the Mulberry Silk Industry.") Price, As. 12 or 1*s*.

Reports.

1. Proceedings of the Second Meeting of Mycological Workers in India, held at Pusa on the 20th February, 1919, and following days. Price, As. 11 or 1*s*.
2. Proceedings of the First Meeting of Veterinary Officers in India, held at Lahore on the 24th March, 1919, and following days (with Appendices). Price, As. 8 or 9*d*.

SPECIAL

INDIAN SCIENCE CONGRESS NUMBER

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ON THE CONTINENT.

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PREFACE.

THE Third Indian Science Congress held at Lucknow in February 1916, was a great improvement on the first and second meetings, and the expectations of the promoters as to the advantages of such meetings were on this occasion shown to be justified. The Indian departmental system of Government is apt to restrict correspondence between members of its numerous scientific departments and public and private institutions and to create a state of water-tight compartments. This is a serious drawback to the interests of scientific progress in a country where most of the scientific work is carried on under the auspices of Government. A Science Congress breaks down these barriers and brings together men of varied shades of opinion in every branch of scientific activity, and enables them to check and discuss problems in a manner for which the ordinary Government reports and publications offer no corresponding facilities. It also aids in the sifting of the good from the bad and gives the public, which is none too well informed on scientific matters, an opportunity of becoming acquainted with the doings of science. For these reasons the Indian Science Congress would seem to deserve every encouragement. It is hoped that it will continue to improve and become a powerful weapon for the aid and advancement of scientific progress in India.

One of the features of the last Congress was the creation of an Agricultural Section in which papers related to problems affecting the agricultural industry were read and discussed. Some of these are of considerable interest, and it is thought that to bring out a selection in the form of a Special Congress Number of the Agricultural Journal of India will be appreciated by the readers of the Journal. This explains the reasons for the present issue.

INDORE :
Dated the 5th May, 1916.

BERNARD COVENTRY.

With acknowledgments to the Asiatic Society of Bengal, under whose auspices the Indian Science Congress was held, for their kindness in allowing us to publish the papers contained in this number *in extenso*.

EDUCATION IN ITS RELATION TO AGRICULTURE.

BY

BERNARD COVENTRY, C.I.E.,

Late Agricultural Adviser to the Government of India and Director of the Pusa Agricultural Research Institute.

" I am no educator, no teacher; I have made no psychological study of young people from an educational point of view, nor of the different methods of teaching suited to different ages, no statistical investigation of the influence of particular curricula in training the mind or furnishing it with useful information. I have, in short, neither made contributions to the science of education nor practised the art ....I can speak only as a member of the general public—not as an expert................not that I regard the view of the general public as unimportant................ The general public must, as all will admit, decide what is to be spent on education or, more strictly, on schools and colleges and professional educators, out of both public and private income—it is for them to decide on its relation to other social and family needs. But the concern of the public with education is not merely financial and administrative. It is more intimate than that. For education is not a subject like physics or chemistry on which only an expert has a right to an independent view. There are, no doubt, aspects of it of which only the expert can properly judge, there are experiments in it which only the expert can advantageously try, and there are, of course, departments of it in which the opinion of the expert is indispensable. But without depreciating either the science and art of education, it is clear that when we take education in its widest sense it concerns everybody and almost everybody is bound to have views about it."

These words were spoken by no less a person than Mrs. Henry Sidgwick in her address as President of the Section on Educational Science at the recent meeting of the British Association at Manchester.

I feel like Mrs. Sidgwick that I am " no educator and no teacher " and that an apology or at least an explanation is required from me for troubling you to-day in a subject on which I am not an expert. But when we have it on such an authority as Mrs. Sidgwick that education " concerns everybody and almost everybody is bound to have views about it " I feel I have a measure of sanction for imposing my views upon you. I do not propose, however, to make full use of this sanction and tell you all I think about education, but I propose to restrict my remarks to education in its relation to agriculture and further with the exception of an introductory statement dealing with a few facts, I do not propose to say much on the education of youth, but of that of the adult. You will probably all admit that this is quite a novel and peculiar way of dealing with the question of education, but I trust you will find it none the less interesting and instructive. I should like to say before I go any further that I claim no credit for the ideas I shall place before you. They all come from America and, like everything that comes from that wonderful country, they are exceedingly " cute " and practical and in my opinion are eminently applicable to India.

The population of British India comprises over 255 million souls. Of this vast multitude 80 per cent. or over 200 millions, that is to say, 4 in every 5 are dependent on agriculture. Any educational system therefore which does not take into consideration the relationship it should bear to agriculture is likely to be at a disadvantage. It is on the importance of this aspect of the educational problem I intend to address my remarks. Now out of the whole population, 7½ millions or about 3 per cent. are scholars, though 15 per cent. or 36 millions are of the school-going age. Thus only 20 per cent. of those of the school-going age receive any education at all. Of these 7½ million scholars, about 1 million proceed to secondary education and about 40,000 reach a University career.

In judging of these figures in relation to the agricultural industry it should be borne in mind that the percentage of scholars is much higher in the urban than in the rural areas and also that a very large number of rural scholars never get more than a mere smattering of the most elementary education; so that educational efficiency in rural areas is very much lower than the official returns of general education would indicate. I may appropriately refer here to a small brochure entitled "A Policy of Rural Education" by Mr. S. H. Fremantle[1], the Collector of Allahabad, which has quite recently been published and which is well worthy of perusal. He complains how both in urban and rural schools education is too literary and how primary schools are worked for the benefit of that small section which can afford a secondary education and not in the interests of the overwhelming majority of agriculturists, most of whom abandon their studies after a few months. I think Mr. Fremantle is right. It means that very few indeed of the agricultural population get any education at all, and that, as a class, it can be put down as almost illiterate. The authorities have not been ignorant of these facts, and it is not from want of trying to improve matters that things are at such a low ebb. Much has been done in recent years to improve our system of education, especially in its relation to agriculture and the subject may be said to have received an unwonted measure of attention. In 1901 an important Conference was held at Simla presided over by Lord Curzon which led to a complete overhauling of the existing educational machinery. A policy of reform was then started, the vitalizing influence of which is felt to this day. A department of education was created with a member of council in charge. Money grants were increased and they have still further increased, as a result of keen interest taken by the present Viceroy, Lord Hardinge, who has made education a special object of his attention. Thus the total expenditure which in 1901 was 4 crores, to-day is over 10 crores. The number of pupils in 1901 was $3\frac{3}{4}$ millions, to-day it is $7\frac{1}{2}$ millions. Interest has been stimulated in every quarter and expansion is noticeable in every branch.

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[1] Fremantle, S. H., *A Policy of Rural Education.* W. Newman & Co., Calcutta.

Agricultural and rural education have had quite a fair share of attention, and the need which exists for connecting the teaching of the schools with our chief industry has been and still is fully recognized. I therefore do not complain of want of endeavour. But it cannot be said that these efforts have been crowned with the success one would have wished. But if we have to admit failure, whether complete or partial, we have gained considerably by the discussions which have resulted and by the light which has been thrown on the difficulties inherent in the problem.

The occasion when agricultural education rst seriously engaged the attention of Government and the people was in 1904, when the policy for improving the agricultural industry was started by Lord Curzon. At first it was the intention to restrict efforts to improving the industry itself, but later, influenced no doubt by the examples of advanced schemes abroad, the Government elaborated a policy under which not only research and experiment, but agricultural education proper, formed an important and integral part. Large sums of money were devoted to the erection of agricultural colleges in nearly all the Provinces. Syllabuses were prepared by the Board of Agriculture and the Colleges were empowered to grant a diploma of Licentiate of Agriculture. At first, signs of success were not wanting. Candidates freely offered themselves for admission and there was found no difficulty in filling the colleges. However, as time rolled on, a decline in admissions became perceptible until the year 1913 when, in some colleges, the position became acute and the matter was brought up for consideration before the Board of Agriculture. The proceedings of the Board in that year indicate the general failure of the schemes drawn up in 1906 and 1908, and we find it expressed that the courses were found not to be suited to the class of students for which the colleges were intended, that the demand and utility for the course is obscured by its being made a road to a degree, that college graduates engaged on the subordinate staff of the Agricultural Department, with very few exceptions, failed to show any power to develop any original line, that intelligent inquisitiveness and power of independent thought was lacking,

that the course engendered too much cram and too little power of application, and so forth. What was the root-cause of this failure would appear to be explained in one of the resolutions which stated "that the general standard embodied in the Matriculation or University Entrance Examination does not provide a sufficient basis to enable a student to take full advantage of the higher instruction obtainable in the existing agricultural colleges in India"[1] and the Board recommended that a general higher education is necessary in all students admitted to such a course. In other words, it would appear that the standard of general education in the country was too low to afford suitable material with which to man colleges of such an advanced type as those which had been set up by the Agricultural Department. In fact, the colleges as educational centres were ahead of the times—primary and secondary education was too backward. Consequently the Board suggested a compromise by lowering the standard of the college curriculum to meet existing conditions and expressed its approval of a two years' preliminary practical course, which had been prepared for the agricultural college at Coimbatore as an introduction to the more advanced course. Many of the colleges have since adopted this, with the result that admissions have considerably increased. While we may expect that the Department will benefit by an increase of recruits for filling its subordinate posts, it has yet to be seen how far the education of the cultivators will be influenced by the change. My own view is that these colleges as instruments for education will not accomplish very much, for the simple reason that they are ahead of the times and that there can be no real demand on the part of the youth of the country for an advanced agricultural course until considerable progress has been made in primary and secondary education and in the improvement of agricultural methods. Not until the industry is more highly developed and the standard of living has been raised, will there arise a demand for higher education amongst the agricultural classes.

[1] *Proceedings of the Board of Agriculture in India*, 1913, p. 42. Government Printing, India, Calcutta.

The creation of agricultural colleges, however, is by no means the only effort that has been made to improve the education of our agricultural youth. Agricultural schools under the supervision of the Agricultural Department have been started in some provinces which were commended by the Board. They give considerable promise of success and, in my belief, deserve every encouragement. Also, there have been attempts in all provinces to set up a system of rural education by imparting instruction based upon the agricultural surroundings of the children, and endeavours have been made to use nature study as a means to that end. But so far the results, we must admit, have been of a microscopic character.

But there is a form of education which is not included in those I have mentioned and is unknown in India. It is a form of education which has been adopted in certain parts of America and which has of late attracted a considerable amount of attention. It is, in my humble opinion, applicable to the conditions existing in India, and offers opportunities in which officers of the Agricultural and Educational Departments could profitably combine to make the problem of education of the masses easier and more efficient. I will give a brief description.

In America general education is carried on chiefly by the Government by whom large sums of money are yearly allotted to the cause of education, but privately supported colleges are abundant and both these and Government schools are largely assisted by private benefactions, the most important of which are controlled by a private body known as the General Education Board.

Ten years ago great interest had arisen in the upraising of the Southern States whose industrial and educational conditions had fallen very much behind those of the Northern States. Conditions in the Southern States resemble in many particulars those which obtain in rural India. About 80 per cent. of the population is agricultural, depending for its livelihood almost entirely on the produce of the soil. There was great backwardness in both educational and industrial progress. Unfavourable economic conditions existed which were mainly the result of rural poverty. While the average

annual earnings of agriculturists in the Northern States were more than 1,000 dollars, those in the Southern States were as low as 150 dollars. Under the auspices of the General Education Board an enquiry was set on foot to study the educational conditions in the Southern States and to devise the ways and means for improving them. The very practical way in which the enquiry was conducted is characteristic of the American people. Surveys were planned State by State, conferences were held, monographs were prepared, dealing with the various points on the organization of education. The conclusions which resulted from this enquiry are peculiar. To quote from the Report, it "convinced the Board that no fund, however large, could, by direct gifts, contribute a system of public schools; that even if it were possible to develop a system of public schools by private gifts, it would be a positive disservice. .... The public school must represent community ideals, community initiative, and community support, even to the point of sacrifice."[1] The Board therefore resolved that assistance should be given not by foisting upon the Southern States a programme of education from outside, but by aiding them and co-operating with them in educating themselves. When, however, it proceeded to apply these principles it was faced with the following initial difficulties. They found the people had not enough money, "that adequate development could not take place until the available resources of the people were greatly enlarged. School systems could not be given to them, and they were not prosperous enough to support them." "Salaries were too low to support a teaching profession................Competent professional training could not exist; satisfactory equipment could not be provided."[2] These conditions were primarily the result of rural poverty. The great bulk of the people was not earning enough to provide good schools and the prime need was money. The Board therefore came to the conclusion that it could render no substantial educational service until the farmers could provide themselves with larger incomes,

[1] *General Education Board. An Account of its Activities,* 1902—1914. 61 Broadway, New York.

[2] *Ibid.*

and consequently they resolved that it was necessary first to improve the agriculture of the Southern States. Now mark what followed. The Board was first advised to address itself to the rising generation and to support the teaching of agriculture in the common schools. But after thoughtful consideration this plan was rejected. They found that in the absence of trained teachers, the effort was impracticable; moreover, there were no funds with which to pay such teachers, and the instruction itself would not materially contribute to its own support. Finally, it was impossible to force intelligent agricultural instruction upon schools whose patrons were not themselves alive to the deficiencies of their own agricultural methods. Until the public was convinced of the feasibility of superior and more productive methods the public schools could not be reconstructed; once the public was convinced and, by reason thereof, better able to stand the increased cost, the schools would naturally and inevitably re-adjust themselves.

"It was therefore deliberately decided to undertake the agricultural education not of the future farmer, but of the present farmer, on the theory that, if he could be substantially helped, he would gladly support better schools in more and more liberal fashion."[1] The Board, therefore, set about an extensive enquiry as to the best means of conveying to the average working farmer of the South, in his manhood, the most efficient known methods of intelligent farming. As a result of this enquiry a movement known as the Co-operative Farm Demonstration was set up. A year was spent in discovering the most effective methods of teaching improved agricultural methods to adult farmers. Dr. Seaman Knapp of the United States Department of Agriculture was engaged to show farmers how to improve their agricultural methods and raise the standard of their industry. It was not long before successful results were obtained. Under improved treatment it may be roughly stated that the crop yields were doubled. Thus in 1909 the average yield in pounds of seed cotton was 503·6 per acre: on demonstration farms the average was 906·1 pounds; in 1910

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[1] *General Education Board. An Account of its Activities*, 1902—1914.

the figures were 512·1 and 858·9 respectively; in 1911, 624·6 and 1081·8; and in 1912, 579·6 and 1054·8.

In the growing of corn similar results were obtained. In 1909 the ordinary average yield was 16·7 bushels per acre, while on the demonstration farms it was 31·7 bushels per acre. In 1910, 19·3 and 35·3, in 1911, 15·8 and 33·2, and in 1912, 19·6 and 35·4. It is further stated that the poorer the season, the more clearly did the demonstration methods prove their superiority. The work was also studied from the standpoint of the farmer's financial profit. "In Alabama, for example, in 1912, the average yield of lint cotton was 173 pounds per acre; but demonstration acres averaged 428·3 pounds. Demonstration methods, therefore, netted the farmer 255·3 pounds per acre. At the average price of 65 dollars a bale for lint and seed, the farmer made an extra 33 dollars per acre; as there were 8,221 acres under cultivation on the demonstration methods, the total gain was 271,000 dollars. In the same year 7,402 acres were under cultivation in demonstration corn. Demonstration acres averaged 26·9 bushels more per acre than the general average for the State. The demonstration farmers of the State pocketed 139,379·66 in consequence."[1] This was of course in one State alone. These methods have not been restricted to cotton and corn, but have been applied to a very large number of crops and the propaganda is not limited to cultural methods, but is applied equally to the improvement in farm equipment, more comfortable houses, better barns, stronger teams, better implements, and cleaner and healthier surroundings. Hence it is claimed that the beneficent results of this work are not limited to financial profit and cannot entirely be measured by money. Characteristic examples of the relief which the new system brought are cited, but one example will suffice. In Mississippi 5 years ago the value of a certain farmer's produce was one dollar per acre and he was 800 dollars in debt. In 1909 his entire farm was worked under the Government method. He averaged 1,100 lb. of cotton against his neighbour's 300 to 400 lb. He made besides 500 bushels of corn and from one

[1] *Ibid.*

special demonstration acre realized 152 barrels of high class seed which he sold for 300 dollars. His debts are now paid and he has cash in the bank. So much for the education of the adult farmer. We now come to the effect this movement has had on the education of youth. We are told that the initiation of demonstration work and the application of the principle of co-operation has resulted in the disappearance of the disorganization characteristic of rural life. Colleges of agriculture, farmers' institutes, agricultural high schools, "Boys' Corn Clubs," "Girls' Canning and Poultry Clubs," and the like have been brought into existence where practically none of these things existed before, and that the social and educational awakening of the rural South is recognized as being a bye-product of the demonstration movement. Statistics show that the provision for schools has steadily increased. Thus the expenditure for public, elementary, and secondary schools in North Carolina which was 1,091,226 dollars in 1901, is 4,300,000 in 1913. In South Carolina the expenditure which was 961,897 dollars in 1901 is 2,609,766 in 1913, Arkansas 1,369,809 and 4,279,478, and so forth. These instances give but meagre examples of the important results achieved by the demonstration movement. For greater detail I must refer you to the Report[1] itself.

I think you will agree with me that the educational policy I have described is novel and peculiar. When I say novel, I do not mean that demonstration work has not been used before among farmers and cultivators. We all know that it has, but it is novel in the sense, that never before, so far as I am aware, has demonstration been used in any country as a force and weapon for education so as to make it a condition precedent to the education of youth. It is a new experiment but a new experiment of a remarkable kind. The results indicate that it is no use to try and educate youth if you do not first secure the welfare of the community to which it belongs and that therefore the development of resources should precede education in order of time. What the American General Board of Education says to the farmer in the Southern States is—You

[1] *Ibid.*

are too poor to supply your sons with education; we could assist you, but we do not consider it proper to do so, unless you yourselves contribute. As you cannot do this, we will assist you to increase your earnings so that you will be in a position to provide yourself with schools. When you have done this we will assist you further. We consider that it would be wrong for us to directly educate the rising generation, if you are not able to participate; in fact, we believe that it would be a positive disservice for us to do so. Your schools should be started by yourselves, they should represent community ideals, community initiative, and community support even to the point of sacrifice.

We have seen how the experiment has succeeded. Might we not with advantage apply the same principles to India? Might we not invite the co-operation of the Agricultural Department in a general scheme and policy of education? Is there any likelihood of success without this? Can we hope to give the youth of this country an adequate educational service unless we go to the root of things, like the Americans have done, and enlist and increase the activities of the Agricultural Department in enlarging the resources of the cultivator and thus build our educational system on the increased prosperity of the agricultural classes? These are the questions I desire to offer for consideration. India is in no better position than the Southern States were ten years ago. Indeed I think we may safely assert it is in a far worse position. The average earnings of individuals in the Southern States at that time were 150 dollars. In India, according to some authorities, under the most optimistic calculations, they are as low as Rs. 30 per head. You must agree this gives little or no scope for self-help. It therefore seems to me plain that under present conditions we cannot expect the country to supply itself with the means for an advanced system of education. Nor can Government be expected to do so, for Government's resources are limited and depend upon taxation, and that in turn depends upon the ability of the people to be taxed. All Government can do is merely to touch the fringe of the problem and supply a modicum of education; it cannot afford to do more. Mr. Fremantle very well describes the situation when he says: "We

should surely pause to consider whether the time is ripe for the introduction of a system of general primary education into rural areas. It is a question whether we are not beginning at the wrong end and whether primary education can make any real advance before there is a substantial improvement in economic conditions."[1] These are words which the devotees at the shrine of the policy of free education for the masses might with advantage ponder.

The question then is whether we can, in any way, make the principles which have been so successfully applied in America, applicable to India. My belief is that we can. We have practically the same conditions here as obtained in the Southern States ten years ago. If anything, as I have shown, they are a good deal worse. But this is no argument against their adoption. Rather the reverse, for the lower the degree of prosperity, the greater is the need for increasing it. Already in the Provinces a great deal has been done by the Agricultural Department in the way of demonstration of the character described and utilized by the American Board of Education. But it does not go far enough. It, however, forms a nucleus on which to expand and might well be used as a beginning. The work is on the right lines. But we require to do more. We want more men, more money, wider organization; but, above all, we require the recognition amongst all classes that in this work lies the germ of future progress. This is a point which is not generally recognized, or, if so, it is certainly not acted upon. While the money spent to-day on education is over 10 crores of rupees, that on agricultural development is only 50 lakhs. That shows that we have not yet got to view these two important problems in their right perspective, and do not fully realize the important relation which agriculture bears to education. Many think that the development of agriculture depends on education, and we gave effect to that view when we started our agricultural colleges. But would it not seem that the truth lies in the opposite direction, and that in a backward country like India the advance of education is really dependent on the development of agriculture, and that the best form of education

[1] "A Policy of Rural Education," W. Newman & Co., Calcutta.

you can give to the rural classes under existing circumstances is demonstration in improved agricultural methods ? It was found to be so in the Southern States of America and we have no reason to suppose it is otherwise in India. To carry out the idea it is not necessary to bring our present educational policy to an end. I would not propose anything so revolutionary. Government must, as I have already explained, supply a modicum of literary teaching and this must continue, but it would be an immense improvement if the Agricultural Department were called in to co-operate and demonstration were given a large share in the general scheme of education.

We could not be expected at first to progress with the same degree of rapidity as in America, because we have to do a large amount of research and experiment before we can demonstrate improved methods on a large scale. In America the advanced stage in the agricultural development of the Northern States supplied ready at hand the stock-in-trade required for at once setting in motion the demonstration movement in the backward Southern States. We are not so forward. Still we have achieved enough with our small band of workers to show that the same kind of work can be done out here and that all we require is expansion. Given the means for this (and who will say it would be a bad investment ?) and a recognition of demonstration as an integral part of a general scheme of education, and I feel sure we shall, by such a policy, lay the best and securest foundations for the advancement of education as well as of the prosperity of the people.

THE APPLICATION OF BOTANICAL SCIENCE TO AGRICULTURE.

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I. Introduction.

A study of the literature dealing with agriculture indicates that there is some confusion of ideas as to the precise relation which exists between the science of botany on the one hand and the practice of agriculture on the other. In the present paper, an attempt has been made to define the bearing of the scientific aspect of the vegetable kingdom on the economic development of crop-production and to show how a knowledge of this science can best be applied to agricultural problems. A new term has recently grown up—Agricultural Botany—and text-books have appeared thereon as if a new branch of the science had been developed. Agricultural botany is supposed to be easier than ordinary botany and to be more adapted to the needs of the students in agricultural colleges. It is often assumed that in such colleges only a rudimentary knowledge of botany is required and that the examples used in teaching must of necessity be taken from cultivated crops. It is even thought that students trained in this manner will develop into investigators and that advances in agriculture can be achieved by such agency. I venture to assert that nothing could be further from the truth and that, in this direction, there is no royal road to success and that the final result of such endeavours can only be disappointment. For any real advance to be made in crop-production, a thorough scientific knowledge of botany in all its branches is one of the first

conditions of progress. This will be clear if the real problems to be solved are considered in all their bearings.

The attempt to improve cultivated crops by scientific methods is a recent development and can be traced to two main causes—(1) the gradual recognition of the fact that in agriculture the plant is the centre of the subject; and (2) the rapid rise of the study of genetics which followed the re-discovery of Mendel's results in inheritance.

Starting from Liebig's application of chemistry to agriculture, an enormous amount of chemical investigation, relating to the composition of the soil and of the plant, took place and for a time great hopes were entertained that in this direction important progress could be made. These expectations were not fulfilled, and gradually the chemists broadened the basis of their investigations and took into consideration the physical character of the soil, its geological origin, and the natural vegetation found growing therein. In this manner, modern soil-surveys have arisen in which the importance of the plant as a living organism has been slowly recognized. Recently, the development of genetics has drawn still more attention to the plant and this recognition is reflected in the present constitution of the staffs of up-to-date Experiment Stations. Side by side with these changes, the studies of disease in plants have to some extent receded in importance as is well seen if the present staff of the Bureau of Plant Industry of the United States Department of Agriculture is compared with that of twenty years ago when this Bureau was almost entirely composed of mycologists and when the advice given by the botanists was largely confined to the treatment of plant diseases.

The importance of the plant in crop-production may be said to be generally recognized at the present time. A large number of botanists are being employed at Experiment Stations and the public have often been led to expect that a revolution is about to take place, particularly through the application of what is popularly known as Mendelism. A critical examination of the literature discloses some signs that these extravagant hopes are not likely to be fulfilled, not that these hopes are impossible but rather because the problems

have not always been taken up on a sufficiently broad basis and attacked simultaneously from several standpoints.

II. The Development of Botany.

A brief review of the manner in which botanical science has developed will help to make clear the great difficulties which must first be surmounted before any results of real practical value can be obtained.

As is well known, the origins of modern botany are to be traced to the old herbals of the sixteenth and seventeenth centuries and to a period when plants were studied chiefly from the medicinal point of view. It was then essentially a field study out of which the modern ideas on classification slowly emerged. The development of the microscope, while leading to immediate and far-reaching advances, necessarily focussed the attention of investigators on the anatomy of plant organs and on the study of the various structures met with in these researches. Similar particularist tendencies arose in the growth of systematic botany and undue attention was often paid to the study of the floras of various regions from the point of view of herbarium specimens alone. The growth of physiology was too slow to remove entirely the evils of a somewhat formal and one-sided development which was reflected both in teaching and research. Physiological investigations are notoriously difficult and the greatest patience and skill are necessary in advancing our knowledge of the various functions in the plant. The manner in which botanical science has developed and the necessity of dealing with large classes of students in Universities, have necessitated a somewhat formal presentation of the subject in separate sections such as morphology, anatomy, physiology, and systematy. Much of this sub-division is inevitable but it renders difficult a proper conception of the plant as a living whole, as a complex factory which takes in, by way of the roots, various mineral salts in solution in water and, by the leaves, oxygen and carbon dioxide from the air, working all these raw materials up into complex food substances by means of energy focussed from the sun through the medium of the chlorophyl corpuscles. The plant is continually manufacturing

new food, developing new organs, and completing its life cycle under constantly varying conditions as regards moisture, food materials, temperature, humidity, and illumination. The vegetable kingdom is like a multitude of exceedingly complicated and competing hostile factories which have to carry on their activities under all sorts of rapidly varying circumstances. Any failure to meet the changes in the working conditions, caused by weather or by shortage of water and mineral salts in the soil, may mean the stoppage of the factory and the extinction of the organism. In this competition, all the combatants are armed to the teeth and possess all kinds of devices to assist in the struggle for existence. If any space in the sun is yielded by one of the competing factories, it is instantly seized by the rest. The limitation of armaments is an impossible conception in the vegetable kingdom. It is no easy task for the student to appreciate fully the many-sided aspects of the living plant and to master the manifold details of a science, still to a large extent in the descriptive phase of development, particularly when that subject is presented to him in parts often very loosely bound together. The investigator too is hampered in this direction by the necessity of specialization and of narrowing down the conditions of a problem so that the ordinary clear cut methods of academic research can be applied. It requires a conscious mental effort on the part of a botanist to regard the vegetable kingdom as a whole and not to think of it only in terms of systematy, physiology, or of anatomy. Training in research in any particular branch does not necessarily widen the general outlook, although it is of the greatest use in other ways.

The more recent developments in botanical science are fortunately all tending to a study of the plant as a living whole. Both the scientific study in the field of plant associations (ecology) and the systematic examination of the various generations of plants raised from parents which breed true (genetics) are doing much to mitigate the evils which follow from undue devotion to purely laboratory work. Ecology and genetics are taking the botanist into the field and will, in all probability, materially influence the future development of the science. This will be all to the good and

should do much both to raise the standard of and emphasize the importance of field work and also develop the natural history side of botany. The botany of the future is likely to combine all that is valuable in laboratory work with modern ideas on ecology, classification, and genetics.

III. The Relation of Botany to Agriculture.

We have seen that from the nature of the subject and arising out of their training, most botanists experience difficulty in realizing fully the plant as a living whole in which one part reacts on another. A wide scientific outlook on the many aspects of plant life is nevertheless the first condition in applying botanical science to practical problems. It is, however, by no means the only one. The next step for the botanist is to study his crop in the field and to learn to appreciate the agricultural aspects of crop-production. In other words, he must study the art of agriculture as applied to his particular problem. Too much stress cannot be laid on this. The investigator must himself be able to grow his crop to perfection and it is not too much to say that no real progress can be made without this. The ordinary agricultural processes applied to any crop bear a direct relationship to the physiological necessities of the plant and have been evolved from centuries of traditional experience. Thus in the growth of *rahar* (*Cajanus indicus*) in many parts of India, it is the custom to dig the land at the end of the monsoon as by this means the yield is increased. The physiological basis of this operation is the necessity for the provision of abundant air for the root-nodules in an alluvial soil consolidated by heavy monsoon rainfall. Indeed the agricultural processes necessary to grow a crop to perfection in India are nothing more than lessons in physiology learnt by experience through a long period of time. In all investigations on crops, a first-hand knowledge of practice is necessary and nowhere is it so important as in plant-breeding work where practice is quite as valuable as an acquaintance with the methods and results of genetics. The greatest devotion to the study of inheritance, using for this purpose material indifferently grown, is largely labour lost as many characters are masked unless the plants are really

thriving and well-developed. For instance in wheat, the red colour of the chaff never develops in badly grown plants thereby causing great confusion in systematic and breeding work on this crop. In tobacco, the various leaf characters are almost entirely masked by bad cultivation and their inheritance can only be studied if the crop is grown to perfection.

The investigator, after having learnt how to grow plants and having mastered agriculture as an art, must proceed to study his crops in the field. It is not sufficient to plant the seed and wait till flowering time and harvest come round for the results. Daily contemplation of the growing crop and observation of the plant through its whole life-history will suggest many new ideas and do much to train the observer, and develop the power of accurate deduction and real agricultural insight. In variety trials and field experiments, the necessity of constant observation of the growing crop is seldom recognized. An even plot of land is selected, the crop is sown and the harvest weighed. Should the season be abnormal, this circumstance is often recorded. It is somewhat dimly perceived that the quantitative results of any year partake of the nature of an accident, but it is thought that a repetition of the experiment for, say, fifty to one hundred years and the striking of an average result will remove most of the effects of disturbing factors. It is true that this expensive and time-consuming procedure will give the mean result under the conditions of the experiment provided all due care is taken in carrying out the work. On the other hand, a constant observation of the growing crop by a fully qualified observer will lead to the deduction of the factors on which yield depends far more rapidly and accurately than can be done by such a mechanical method. Constant observation of the growing crop is therefore of the first importance. In course of time, the observer learns how to read his practice in the plant and, at the same time, he develops from hardly won experience a sympathy and understanding of the cultivator and of the grower's point of view. The raising of crops is a most useful discipline for a young investigator fresh from the university, and it also serves rapidly to remove any intellectual arrogance he may possess in his attitude

towards the farmer or cultivator. First-hand practical experience will thus assist towards producing a proper relationship between the scientist on the one hand, and the practical man on the other. This apprenticeship will, at the same time, serve to eliminate at the outset men who lack a practical turn of mind. The agricultural public judges largely by eye, and is not trained in the rapid digestion and understanding of printed reports. Well grown crops at an experiment station are much more telling than printed bulletins however well-illustrated these may be. In dealing with the would-be improver, the attitude of the agriculturist is often one of amused scepticism as, among themselves, deeds always count much more than words and the benefits of education are not always regarded with enthusiasm. "Show me thy cultivation and I will tell thee what thou art" is merely putting into words the view of the countryside towards a new arrival in its midst. The agricultural investigator must also pass through this ordeal with credit to himself before he can hope to establish his position and hold his own with the tillers of the soil.

Science and practice must be combined in the investigator who must himself strike a correct balance between the two. The ideal point of view of the improver is to recognize agriculture as an art which can best be developed by that instrument called science. Once this is fully realized and acted upon, the place of the experiment station in agriculture will be understood as a matter of course and the qualifications needed by the workers will be self-evident. There will be little or no progress if practical agriculturists are associated with pure scientists in economic investigations. This has often been tried and has never yielded results of any importance. The reason why such co-operation fails is that without an appreciation of practice, the scientist himself never gets to the real heart of the problem. The history of the indigo investigations in India is a very good case in point. During the last 20 years, a number of scientists have been employed in an endeavour to improve the production of natural indigo. Over £50,000 have been expended on this work between 1898 and 1913 but no results have been obtained, largely because the scientists preferred to engage European

assistants on indigo estates to grow their experimental crops rather than to cultivate them themselves. The result was that the real problems were not discovered, a large amount of ineffective work was done and valuable time was lost during which the natural indigo industry declined and the synthetic product rapidly established itself in the markets of the world. The solution of the indigo problem has recently been disclosed by a study of the plant in the field. It is not too much to say that if a properly qualified botanist with a knowledge of agriculture had attacked the indigo problem twenty years ago, the history of this industry would have been very different.

There remains for consideration the commercial aspect of investigations on crops and the necessity, on the part of the worker, of keeping in close touch with the requirements of the trade. Particularly is this important in the case of materials used in textile industries like cotton where any marked alteration in the raw product might easily involve extensive changes in machinery. In the case of cereals like wheat, it is necessary in improving the variety to follow closely the needs of the manufacturer and to ensure that any new types introduced into general cultivation can be milled to advantage. If grain quality, of increased commercial value, can be secured as well as higher yielding power, the combination is all to the good. The investigator must therefore study trade requirements and be able to make use of the experience and knowledge ot the men who handle and use produce on the large scale. The successful merchant often possesses information which is of the greatest value to the botanist and which helps the investigator to perceive the manner in which an improvement can most effectivel be made. Just as the success of a commercial man depends on his ability to determine the direction in which he can improve his method or his product above those of his competitors, so the investigator must possess a similar practical instinct. He must be able rapidly and unerringly to decide in which direction the maximum improvement is possible.

That a combination of science, practice, and business ability in the same individual is essential in all agricultural investigations

dealing with the plant will be evident if the kind of problem awaiting solution is considered in detail. Many of these questions fall into the following three classes :—

(1) *Improvements in the efficiency of the plant.* If we regard the plant as a factory and a crop as a number of factories, the aim of the grower is to produce the largest possible output of some plant product—seed, leaves, roots, stems, or flowers. In stimulating a crop to produce the maximum in any one direction, the factory as a whole must be considered and the machinery must not be thrown out of gear. The physiological aspects of growth must be clearly kept in mind as well as the conditions under which the translocation of reserve foodstuffs takes place. We can, for example, often increase the yield of leaf in a crop like tobacco by suitable manurial treatment such as a copious supply of nitrogenous food material, but the resulting loss in quality is so great that the extra weight would result in financial loss. We should merely produce in this way badly ripened leaves in which the proper development of colour and flavour during curing would be impossible. Any attempt to increase the output of a crop can only be successful if the physiology of the plant is considered together with the economic aspects of production. Such problems have to be solved within the working conditions of the plant factory and also within the general economic limits imposed by labour and capital. In such matters, the investigator might easily go astray unless he keeps the laws of plant physiology in view and unless he is fortified by a knowledge of practice and an appreciation of the general working conditions.

(2) *The treatment of disease.* The inadequacy of much of the experiment station work on the diseases of plants, in which fungi and insects are concerned, has recently been referred to by Professor Bateson[1] in one of the sectional addresses to the British Association :—

" Nowhere is the need for wide views of our problems more evident than in the study of plant diseases. Hitherto, this side

[1] *Report of the British Association for the Advancement of Science*, 1911, p. 590.

of agriculture and of horticulture, though full of possibilities for the introduction of scientific method, has been examined only in the crudest and most empirical fashion. To name the disease, to burn the affected plants, and to ply the crop with all the sprays and washes in succession ought not to be regarded as the utmost that science can attempt. There is at the present time hardly any comprehensive study of the morbid physiology of plants comparable with that which has been so greatly developed in application to animals. The nature of the resistance to disease, characteristic of so many varieties, and the methods by which it may be ensured, offer a most attractive field for research, but it is one in which the advance must be made by the development of pure science, and those who engage in it must be prepared for a long period of labour without ostensible practical results."

A diseased condition in a plant usually arises from some profound interference with the normal physiological processes after which a pathological phase gradually develops. The protoplasm and cell-sap become charged with waste products and a parasitic fungus is then able to destroy the tissues. An invasion of fungus mycelium is usually impossible when the plant is in health as protoplasm is strong enough to resist any attack and the cell-sap is not in a suitable condition to nourish the fungus. The parasitic fungus and the destructive insect are often consequences rather than the real causes of disease and are merely the last phase in the death of a moribund organism. The Java indigo crop in Bihar[1] has recently furnished an interesting example of the necessity of a wide outlook in the investigation and treatment of plant diseases. A diseased condition, known locally as *wilt*, began to make its appearance some years ago after which it rapidly spread all over Bihar. About the middle of the monsoon, the plants were observed to drop a good deal of leaf and the remaining foliage was seen to change in appearance, becoming a greyish, slaty colour. Growth finally ceased after which the plants slowly died during October and November. Not only was

[1] Howard and Howard, *The Improvement of Indigo in Bihar*, Bulletins 51 and 54, Agricultural Research Institute, Pusa.

the yield of dye seriously reduced, but the affected plants yielded hardly any seed. For this reason, the area under Java indigo in Bihar rapidly fell from 70,000 bighas in 1910 to about 15,000 bighas in 1913. Investigation of this disease yielded no results, and it was found that none of the insects, fungi, or bacteria associated with the affected plants were responsible for the trouble. For the moment, science seemed entirely at a loss in suggesting any practicable means by which the final extinction of the indigo industry could be prevented. In reality, however, the position was in no respect hopeless. Examination of the affected crop showed that the leaf-fall and wilt were connected with the destruction of the active root-system of the plant, including the nodules, as a result of interference with the air-supply of the roots brought about by a constantly wet condition of the soil during the long monsoon phase. The wilt disease was found to be the last stage in starvation caused by the cutting off of the supply of one of the essential raw materials—air—needed by the roots and root-nodules. Evidently the line of attack lay in the direction of increasing the air-supply in the soil and in assisting the plant to withstand the constantly moist soil conditions which set in during the monsoon. This was done by improving the methods of cultivation during the hot weather and by the provision of surface drainage, by which each field was cut off from the run-off of other areas by a suitable arrangement of trenches. The problem of the seed supply was solved by August sowings on high-lying, well-drained fields. In this manner, the plants were able to withstand the wet soil conditions of the second half of the monsoon without injury and to yield fine crops of excellent seed. The yield of dye was materially increased by thorough cultivation in the hot weather combined with surface drainage. The history of the indigo disease in Bihar furnishes a very good example of the necessity of a broad outlook in dealing with diseases of crops and for regarding the plant as a complex factory in which injury to any one part often upsets the whole machinery.

(3) *The creation of improved varieties.* In the development of an industry like the manufacture of cotton cloth from the raw material, there is, as is well known, a constant substitution of the

existing machinery by improved types and the scrapping of old plant is continually taking place. In like manner in agricultural development, the substitution of existing varieties by improved forms is constantly being carried out, and in many European crops the varieties grown a hundred years ago have almost disappeared. In crop-production, as in cotton factories, the size of the scrap-heap is one of the indications of the rate of progress. The creator of new varieties of plants must obviously be even better fitted for his task than the engineer who improves spinning and weaving machinery. In a cotton factory, improvement can be made in detail whereas, in the plant, the whole factory must be replaced by a new one and the variety changed. To develop an improved variety and to utilize botanical science to the best advantage, it is clear that the problem to be attacked must first be understood in all its bearings. We require to know by experience the general agricultural conditions of the tract in which the improved variety is to be grown, the kinds at present cultivated, the directions in which improvements are possible, and where the greatest economic advantage can be obtained. In other words, the problem must be simultaneously considered both from the standpoint of the cultivator and from the point of view of the trade. An understanding of the needs of the crop and a knowledge of systematy and genetics must be combined with the insight of the inventor. In such work, no possible scientific method can succeed without the intuition of the breeder. Any attempt to measure or record the characters of large numbers of plants and to obtain the final selections by a scientific system of marks is hopeless, as the investigator would be speedily swamped by the volume of his material. The insight of the breeder is necessary for the work and the judgment, which comes by practice, in the rapid summing up of essentials by eye is far more useful than the most carefully compiled records or any system of score cards. The successful plant breeder is to a large extent born and not made as is proved by the fact that without the aid of science great advances have been made in the breeding of stock, cereals, and in various branches of horticulture. Science helps the born breeder by providing him with new and better instruments and, by bringing knowledge to bear

from many sides, it accelerates the output and lightens the work in a multitude of ways.

In the limits of this paper, an attempt has been made to indicate the class of problems in plant-production which await solution if progress in agriculture is to be obtained by the aid of botanical science. These problems are not simple, and often cannot be solved by the ordinary methods of academic research. Many of them can, however, be dealt with successfully if attacked simultaneously from several standpoints provided always that the investigators themselves are fully qualified for the work. As far as crops are concerned, progress can best be made by botanists, well grounded in pure science, who, at the same time, possess sufficient aptitude to master agriculture as an art and who also have the type of mind to be found in the successful inventor. In this direction, the field of work in the Empire is almost unlimited and the great universities, by helping to train the investigators of the coming generation, have a truly Imperial task to perform. Failure on the part of individuals will occur in the future as in the past, but one great cause of want of success will be removed if the all-importance of agriculture as an art in the equipment of the next generation of experiment station workers is recognized by all concerned. The State can do much in these matters by a practical recognition of the principle that the labourer is worthy of his hire and that the man, who makes two blades of grass grow where one grew before, deserves well of his country, and must be promptly and adequately remunerated.

IMPORTANCE OF SOIL-AERATION IN FORESTRY

BY

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FOREST officers have long realized the importance of soil-aeration in Forestry in so far as this is connoted by such general expressions as "the physical condition of the soil," "water-logging," and so forth. The aspect of this question dealt with in the present paper, however, is one which has not yet attracted the attention it deserves, *viz.*, the damage that may be done to the seedlings of our forest trees by insufficient soil-aeration when the physical condition of the soil is apparently suitable for growth and when the soil, although moist, is far from being saturated with water. The results noted in this paper refer, it is true, to a single species only, *viz.*, the *sal* tree, *Shorea robusta*, but it is believed that they will be found to apply to a number of other species.

The seedling reproduction of *sal* in our Indian forests is by no means satisfactory. In many forests where conditions seem favourable no seedlings exist, and in others the seedlings die back for several years. Plate 1, fig. 1 shows examples of *sal* seedlings which have died back for several years and which are typical of the majority of those found in the protected forests of Northern India. Note the thickened rootstocks and comparatively feeble shoot development. This dying back is usually considered to be due to drought. The whole plant here dies annually with the exception of the stout portion just below the ground level which persists and gradually increases in size and length until finally a persistent aerial shoot is also developed. This delay in the establishment of seedlings interferes with the economic management of our forests and entails a financial

sacrifice in the loss of several years' increment. Drought, however, obviously cannot explain why seedlings frequently die wholesale during the rains nor why the dying-back is frequently more marked in the moist soil of the shady forest than in the drier soil in the open.

The following results dealing with the causes of the death and dying-back of *sal* seedlings have now been established by work recently carried out at Dehra Dun :—

(1) Seedlings grown under favourable conditions of soil and moisture in the Dehra garden do not, as a rule, die back. A few weakly individuals do die back, but the majority produce vigorous shoots which persist from the first and attain an average height of 13″ in one year and 26″ in two years.

Plate I, fig. 2 shows such seedlings one year old and also some weakly plants of the same age which have died back. These vigorous garden plants indicated the development which was possible under the local climatic conditions and the chief object of the present work was to attain or approach this ideal in the local forests.

(2) An experiment carried out in the Dehra garden, in 1913, showed that, if rain water was allowed to accumulate in non-porous pots, in which the basal drainage holes were tightly corked, and which were filled with the local *sal*-forest soil, the latter was soon rendered entirely unsuitable for the growth of *sal* seedlings, although it was by no means saturated with water. It was found that, under these conditions, 100 per cent. of *sal* seedlings were either killed or had their roots extensively rotted when the water-free air-space in contact with their roots was maintained at 450 c. ins. per c. ft. of soil, or less, for a period of 6 weeks, while seedlings in the same soil, in similar pots, but which were uncorked, remained healthy. This experiment was repeated in 1915 with practically the same results.

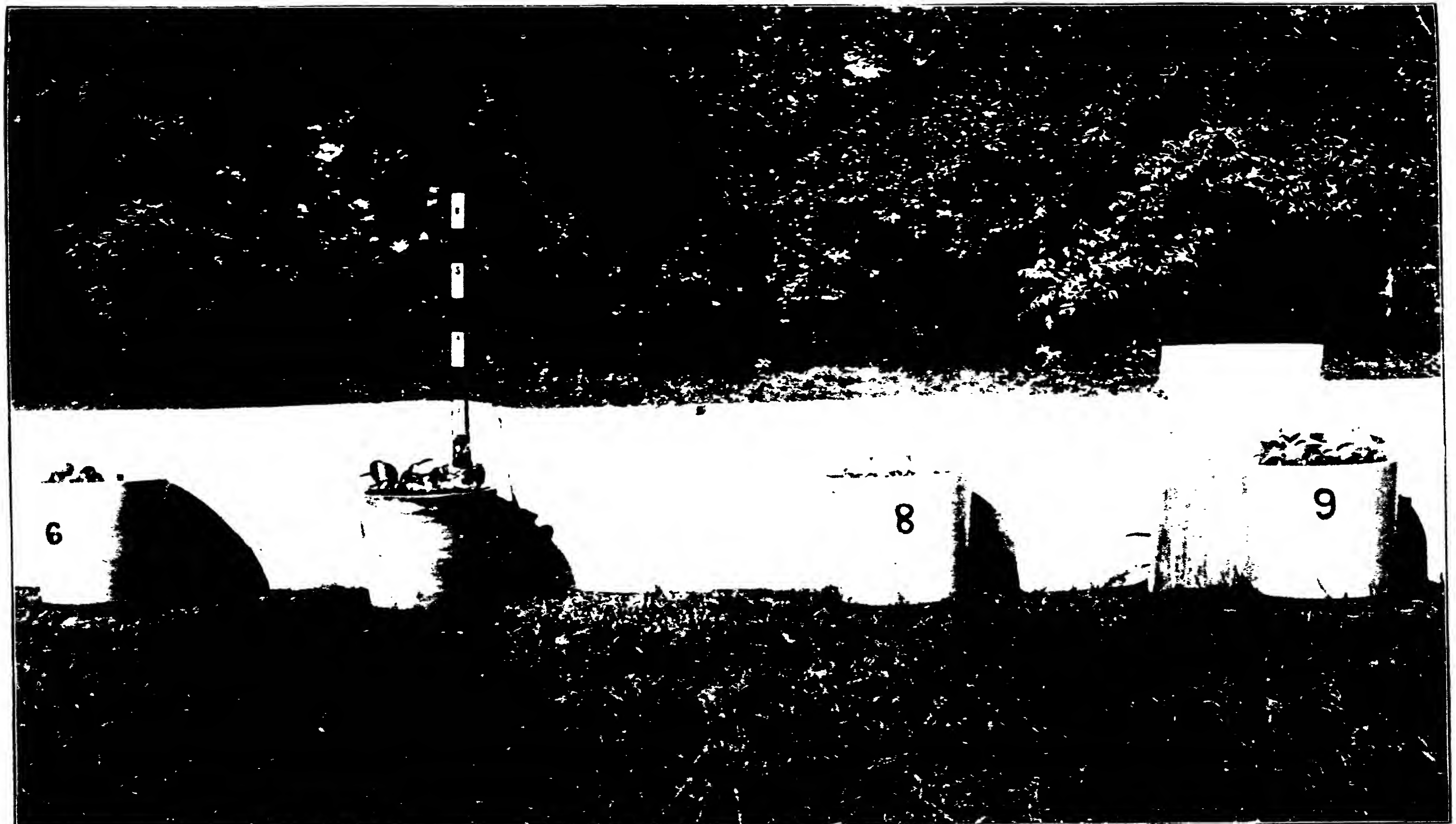
Plate II shows the appearance of the seedlings in these pots in September 1915. Note the healthy plants

Fig. 1.

Sal seedlings typical of those found in the protected Dehra Dun forests. These have greatly thickened rootstocks and have died back for several years. The measuring staff appearing in this and the subsequent figures shows lengths of 6 inches, alternately black and white.

Fig. 2.

Sal seedlings, 1 year-old, grown under favourable conditions of soil and moisture in Dehra Dun Experimental Garden. The five small plants have died back. The majority of the plants, however, do not die back under these conditions and the four large specimens are typical of these. Such vigorous plants attain an average height of 13. 6 inches, in 1 year and 26 inches, in 2 years. This may be regarded as the ideal seedling development possible in the locality.



Photograph taken 20th September 1915, showing *Sal* seedlings growing in *Sal* forest loam. Note the healthy growth in the uncorked pots 7 and 9, as compared with that in pots 6 and 8 which were corked on 30th July 1915.

in the uncorked pots 7 and 9 as compared with those in the corked pots 6 and 8.

This strongly injurious effect on *sal* seedlings of a constantly moist condition in loam was also obtained in an earlier experiment in which good basal drainage was provided, but in which the soil was kept constantly moist by merely diminishing the evaporation from the surface.

(3) Sowings in 1912-13 in sample plots in the shade of the local *sal* forests and on similar soil in the open outside the forests, respectively, resulted at the end of the first rains in 7 per cent. and 37 per cent., respectively, of healthy plants, calculated on the number of seeds sown. Similar sowings in the following year resulted in 17 per cent. and 86 per cent., respectively, of healthy plants. In these experiments the death of the large number of seedlings in the shade was preceded by more or less extensive rotting of the root. During the rains of 1912 the surface soil of the shade plots did not contain more than 400 c. ins. of water-free air-space per c. ft. of soil, whereas the soil of the open plots contained considerably less water and more water-free air-space. It will also be seen that, in the shade plots, the water-free air-space was actually less than has been proved to be highly injurious in the same soil in non-porous pots. In the dry season following the rains of 1912 more seedlings died of drought, during the months of least rainfall, in the shade than in the open plots. This was explained by the fact that, although there was practically no difference in the soil-water-content of the open and shade plots, respectively, at a depth of 3–9″ during this period, the roots in the shade had attained, by May 1913, an average length of 6″ only, as against an average length of 18″ in the open. The plants in the open, therefore, having their roots in the deeper moister soil layers were comparatively safe from damage by drought.

Plate III, fig. 1 shows a typical shade plot at the close of this experiment in July 1915. Notice the absence of vigorous seedlings in the seed-bed. Plate III, fig. 2, on the other hand, shows one of the open plots in the same month. Note the numerous healthy plants.

(4) Sowings, in 1913, in large pots filled, some with clean sand alone and others with a mixture of clean sand and dead *sal* leaves, which were sunk in one of the shade plots of the previous experiment resulted in a percentage of 82 healthy plants at the close of the first rains, as compared with 62 per cent. obtained in the adjacent soil from which the dead leaves and humus had been cleared for two years and 16 per cent. obtained in the same soil with which dead *sal* leaves had been mixed. The root development in the sand was also materially better than that in the adjacent soil. As the plants, in this experiment, were exposed to practically identical conditions of light, temperature, and air-humidity, this indicates that the unsatisfactory development of seedlings in the shady forest is primarily due to a soil factor and not to deficient light, unsuitable air-temperature, or air-humidity; also that the injurious effect is increased by an admixture of dead *sal* leaves with the forest soil and is inoperative in a well drained sand even when dead *sal* leaves are mixed with it. Other experiments have indicated that the effect of this soil factor is progressively diminished by repeated working of the soil coupled with removal of the humus.

With reference to the chief object of the present work, *viz.*, the establishment of vigorous seedlings in the local forests, the experiments detailed above indicated :—

(1) that an injurious soil factor was chiefly responsible for the unsatisfactory seedling development by causing high mortality during the rains and subsequently a high percentage of deaths from drought owing to poor root development;

Fig. 1.

Forest shade plot XI. Photograph taken 20th July 1915, 2 years after sowing. Note the absence of vigorous seedlings in the seed-bed.

Fig. 2.

Forest plot VIII, in the open. Photograph taken 20th July 1915. Note the numerous healthy 2-years-old seedlings surviving in the plot.

(2) that this soil factor could be put out of action by sufficiently good soil-aeration.

It appeared probable, therefore, that clearing the forest growth and exposing the soil freely to sun and air would produce the soil conditions necessary for successful growth, provided that the area cleared was sufficiently small to ensure the light side-shade necessary in Northern India for protection from frost. In 1913, therefore, two adjacent sample plots were selected in a portion of the Dehra forests where sowings in the previous year had given unsatisfactory results.

Above one plot, the overhead cover was entirely removed, before sowing, by felling all trees above and in the immediate neighbourhood of the plot, the total cleared space having a diameter of 60 ft. or a little less than the height of the surrounding trees. In the adjacent shade plot the cover was kept intact. At the close of two years, the percentage of healthy plants in the shaded and cleared plot, respectively, was 34 and 59, the percentage of the surviving plants which had not died back was 10 and 25, while the average height of the plants was 5″ and 12·4″, respectively. The fact that the ground was worked and dead leaves removed for two years in succession was responsible for the results in the shade being considerably better than usual, but there can be no question as to the marked superiority of the open plot. In the cleared plot also, taking only the 4 best plants (which would be sufficient to stock the area of the plot, *viz.*, 18′ × 3′), their average height was $20\frac{1}{2}$″ which fairly closely approaches the ideal seedling development for the locality which was noted at the beginning of this paper *viz.*, 26″.

Plate IV, fig. 1 shows the shade plot and Plate IV, fig. 2 the cleared plot at the close of this experiment in July 1915.

The conditions necessary for the successful growth of *sal* seedlings, therefore, may be said to have been determined as follows :—

(1) a well aerated seed-bed free of raw humus;

(2) full overhead light;

(3) light side-shade sufficient to prevent damage from frost and to keep the soil moist in the dry season.

As regards the identity of the injurious soil factor alluded to, all the facts hitherto ascertained indicate that it can be rendered

innocuous by sufficiently good soil-aeration and, for the present, it may be conveniently indicated by the general term bad soil-aeration. It is not at present possible to define it more exactly or to indicate the precise way in which good aeration renders it innocuous. One thing, however, is clear, *viz.*, that the injurious action is not due merely to an excess of water in the neighbourhood of the roots. This has been praved by a water-culture experiment carried out at Dehra Dun during last rains, in which the injurious factor was found to be practically inoperative. In this case, after 75—78 days in the water-culture, only 8 per cent. of the *sal* seedlings died and the average length of healthy root in the surviving plants was 5·9." A simultaneous culture in badly aerated soil for a period of only 67 days resulted in 93 per cent. of deaths and an average length of healthy root of 1" only. Plate V, fig. 1 shows the appearance of the seedlings after 75—78 days in the water-culture and Plate V, fig. 2 shows the root-development of 6 typical specimens.

Other factors possibly concerned are the lack of sufficient oxygen for root respiration and the production and accumulation in injurious quantities in the soil of one or more substances which are directly poisonous to the roots. Further work is required to determine the relative importance of these factors. In the meantime, however, it is interesting to note that Mr. C. M. Hutchinson, Imperial Agricultural Bacteriologist at Pusa, who kindly examined samples of the soils from the corked pots mentioned in the above experiments, has found bacterio-toxins in all of them. These toxins are said to be capable of inhibiting nitrification and of directly injuring seedlings.

In conclusion, it may be noted that the accurate identification of this soil-factor is important for Indian Forestry, not only on account of its effect on seedlings, but also because of its possible action on older trees. There is reason to believe, for example, that, in the wet *sal* forests of Assam and the Bengal Duars which enjoy an annual rainfall of some 200", the intensity of this injurious factor progressively increases with the age of the forest and materially affects the health of the older trees—possibly preparing the way for the attacks of injurious soil fungi and other parasites.

Fig. 1.

Forest shade plot V. Photograph taken 20th July 1915. Note the appearance of the 2-years-old seedlings surviving in the plot.

Fig. 2.

Forest Plot IV. An area 60 ft. in diameter was here clear-felled in May, 1913. The photograph was taken on 20th July 1915. Note the vigorous 2-years-old seedlings surviving in the plot.

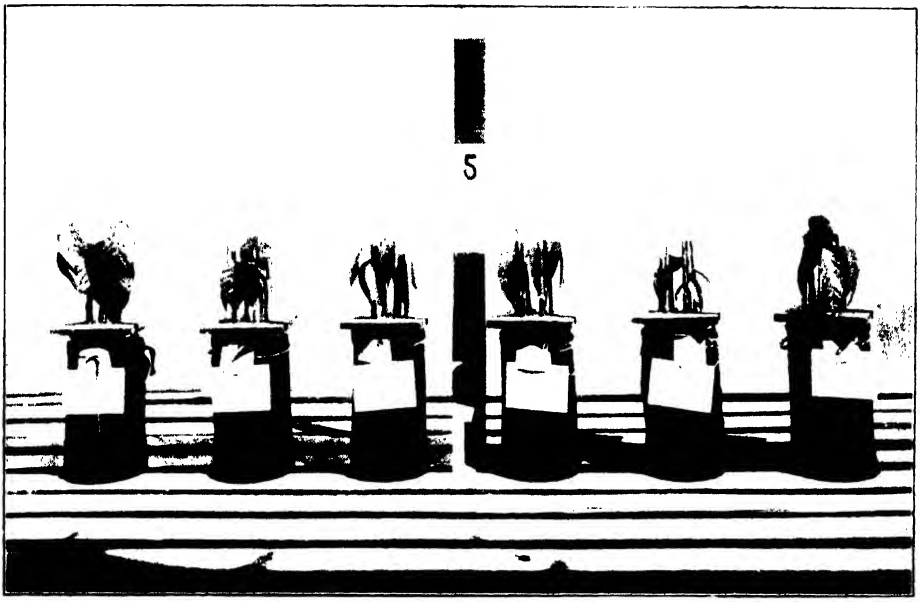


Fig. 1.

Photograph taken 27th October 1915, showing 12 *Sal* seedlings which have been grown continuously in a water-culture solution for a period of 75 (in the case of four plants on the right) to 78 days (in the case of 8 plants on the left.)

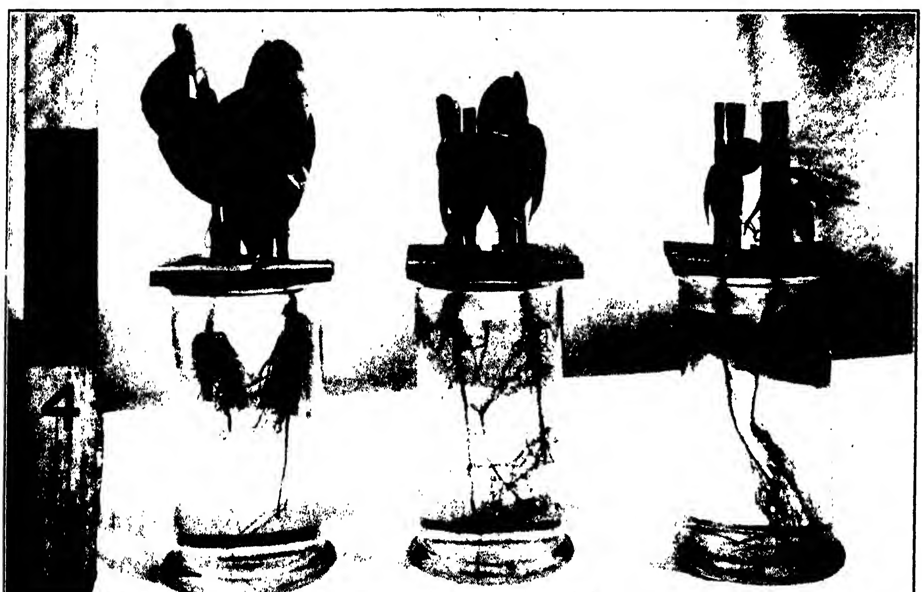


Fig. 2.

Photograph taken 27th October 1915, showing the root-development of 6 *Sal* seedlings which have been grown continuously in a water-culture solution for 78 days, in the case of the 4 plants on the left, and for 75 days, in the case of the 2 smaller plants on the right.

THE RE-ALIGNMENT OF AGRICULTURAL HOLDINGS.

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Most countries with a large peasant population have found it necessary at some time or other to introduce legislation for the re-alignment of holdings to enable the available land to be more economically and efficiently cultivated. The subject has been ventilated from time to time in India but little has been done. It is true that the waste of irrigation water, caused by the present haphazard system, has often been insisted upon, and in the Punjab care has been taken to avoid this on the great new canal systems. Near Poona in the Bombay Presidency the Irrigation Department is now engaged on the squaring up of fields and the drafting of rules to enable greater economy of distribution to be effected on the small, but important, canal systems which are chiefly used for sugarcane. Generally speaking, however, the advocate of re-striping is looked upon as an impatient idealist whose methodical soul is vexed by the present irregular field boundaries.

It has to be admitted that there are great practical obstacles in the way. The present land tenure system of the United Provinces, especially in that portion which comes under the Agra Tenancy Act, makes it exceedingly difficult to alter field boundaries without infringing vested interests. An occupancy tenant possesses cultivating rights in a definite plot of land, which may be only a fraction of an acre in area, and not only can he not be dispossessed, but there is no legal way in which his occupancy rights can be purchased from

him except in those cases where land is acquired by Government. Nor is the ownership of land any more simple. Many villages are now owned by a number of petty zamindars whose land is scattered in different parts of the village, so that any arrangement for general betterment by consent is practically impossible. It is obvious, therefore, that progress in this direction could only be made with the aid of special legislation.

The natural obstacles being what they are it is essential to show that the economic benefits to be derived from re-striping are such as to justify the necessary measures. It may be noted, however, in passing, that the present situation is largely the result of legislation undertaken within the last fifty years. The whole of the Indian land tenure system is based on the assumption that all land is the property of the state. The present system of landlords, with the private ownership of land, is a comparatively recent creation following on British rule and based on English analogies. Introduced as it was to save the agriculture of the country from the evils of the system of farming out blocks of land to contractors for the collection of revenue, it has largely justified itself, and the same may be said to be true of the tenancy laws which were introduced to further protect the tenant. It is only natural, however, that legislation introduced to meet pressing political needs should fail to take account of the effect on subsequent economic development. Should it be found that the tenancy laws in their present form are creating a new evil by checking economic development a strong case for their further modification would exist.

The present scattering of parts of a holding in different parts of the village, which is perhaps one of the first things which strikes the student accustomed to the compact farms of the west, is largely a result of the existing scheme of village life. Instead of each tenant residing on his holding it is usual to find all living in a central *basti*, even if it involves journeys of two or three miles for himself and his cattle. The system is wasteful of labour and cattle power and also of manure but has certain advantages. It doubtless arose when the mutual protection of life and property was more essential than at present, but it is unlikely that the present social organization

will be greatly disturbed in the near future, though signs are not wanting of a steady tendency to form smaller sub-villages nearer to the fields. While it is doubtless of some advantage to the individual tenant to have his holding spread over the different classes of available land, the system suffers from the disadvantage that there is less encouragement for a cultivator to concentrate attention on handling one class of soil adequately. Were this, however, the only point to be gained by the re-alignment of holdings one would be inclined to allow it to come about gradually as the result of changing social and economic conditions.

The greatest disadvantage of the present system, however, is that it prevents any tract of land from being treated as a whole and general measures taken for its improvement. The greatest limiting factor in Indian agriculture is undoubtedly the water-supply, and it is extremely difficult to take steps to improve existing conditions with the present system of holdings. In canal-irrigated tracts the area irrigated is almost invariably much less than the area commanded by the canal. The main great irrigation sources of the Province have already been harnessed and further development must either take the form of better economy in the use of the existing sources or the exploitation of schemes involving greater working cost and often higher capital expenditure and, therefore, more expensive water. It is commonly accepted that, from the great canals only about one-third of the water reaches the field, and that while some margin exists for the reduction of the amount of water actually applied the main losses occur in the canal channels and in the subsidiary village channels—which share the loss fairly equally. The prevention of loss by seepage from canal channels is beyond the scope of the present paper, but it may be noted in passing that any radical measures in this direction must involve additional capital outlay and, therefore, either a rise in the canal rates or better utilization of the water. The loss in village channels is to a great extent avoidable. At present the village water courses follow field boundaries and are consequently unnecessarily long and tortuous and often undesirably aligned as regards levels. While steady improvement in this direction is being effected

through the influence of irrigation officers many of the worst cases cannot be touched. Nor is the situation appreciably better in tracts which depend on wells for their irrigation. The channels from these also are often unnecessarily long and devious, and the scattered ownership of the small fields often puts obstacles in the way of the construction of much needed wells. With more compact and better aligned holdings there would be a greater incentive to the construction of larger wells (or of tube wells) enabling a larger area to be irrigated with less labour. Recent experiments seem to indicate that there is a great future for the employment of oil engines and pumps both on the best masonry wells and on tube wells, but with holdings in their present form, economical distribution of the water is difficult and in many cases so many small interests are involved that it would be difficult to meet them all.

It would be easy to cite many other instances of indirect disadvantages for which irregular field boundaries are responsible, *e.g.*, the absence of decent roadways to give access to the fields, difficulties as regards threshing floors and the carriage of produce and manure, but it is sufficient to say here that they all share one feature, *viz.*, that, except in the case of works undertaken by Government, armed with the powers of the Land Acquisition Act, progress is almost impossible under present conditions.

It is now proposed to consider the effect of present conditions on the actual cultivation of the land. The maintenance of correct levels in a field during all processes of cultivation is recognized in most countries as one of the essentials of good farming. In the Gangetic plain, with an exceptionally easily worked soil, the results of carelessness in this direction are not so readily noticeable, but, on the other hand, the nature of the climate—characterized by heavy falls of rain confined to certain periods of the year and that (in the case of cold weather crops) not the growing season—makes the conservation of rain-water and its correct distribution on the land of vital importance. It being almost impossible to correctly plough a small irregular field, it is not surprising that most cultivators' fields show bad patches which are frequently due to nothing more than faulty levels. The lower patches are water-logged during

the monsoon while the higher patches dry out too quickly in the cold weather. Even the best cultivators' fields are frequently saucer-shaped, with the result that there is water-logging in the centre and consequently a poor crop. When any form of iron plough is used to improve the general cultivation, the difficulties are accentuated as the deeper and more thorough the cultivation, the greater the necessity for the maintenance of correct levels. Simple as it may seem, there are few agricultural officers who have not been confronted with this cause of loss of yield at some time or another. The explanation as to why even comparatively slight and temporary local water-logging causes serious loss is probably to be found in the fact that successful cultivation in the plains of India largely depends on the maintenance of a suitable environment for nitrogen-fixing and nitrifying organisms during the monsoon period. Local water-logging during the monsoon, producing temporarily anaerobic conditions, causes a loss of available nitrogen and hence a diminished crop. The experiments carried out by Mr. and Mrs. Howard at Pusa show that not only does the wheat crop on water-logged land yield far less than on properly drained land, but that the result can be partially remedied—but at additional cost—by the application of nitrates. Generally it may be said that the present small and irregular fields common in many parts of this province seriously militate against the adequate conservation of soil moisture and the maintenance of fertility and, therefore, cause direct loss of produce. Further, they discourage the introduction of the more expensive improved ploughs and cultivating implements as it is difficult to work these to advantage in small irregular fields, whereas if the fields were decently aligned there is reason to believe that joint ownership of such implements would be practicable.

In no direction, however, is the need for the re-striping of holdings more clearly seen than in the problems of checking erosion and effecting adequate drainage. The question has been fully dealt with by Howard[1] so that it is sufficient here to deal with its main aspects only. We are so accustomed to think of the plains of India as flat

[1] Howard, A. Soil Erosion and Surface Drainage. *Bulletin* No. 53 *of the Agricultural Research Institute, Pusa.*

that we are apt to overlook irregularities which, small as they are compared to the hill systems of other countries, are sufficient to be of a great importance in a country of heavy rainfall. As is pointed out by Howard comparatively gentle slopes are sufficient to allow large quantities of the finer particles to be removed from the higher lands to the lower with the result that the physical texture of both deteriorates. The high lands are annually denuded of their finer particles and the fertility and moisture-retaining capacity adversely affected. The low lands, constantly receiving the run-off from the high, are annually receiving unneeded additions of fine silt thus becoming heavier and less workable and in addition receive an excess of water preventing adequate cultivation in the rains and causing a direct loss of fertility. Figures are published in the Cawnpore Farm Report for 1915 which show that the introduction of suitable catch drains on an area of this type has made it possible to raise a normal good crop of wheat on land that a few years ago had to be thrown out of wheat cultivation on account of the water-logging that took place in the rains. On a larger scale the recently opened Kalianpur Farm provides an example of a piece of land, previously only barely culturable, which has been converted into a good farm by proper terracing and correct laying out ; the capital value of the land, as judged by its yielding capacity, has trebled in about 5 years. Operations of this nature, however, require control over a considerable area. Given this control it would not be difficult, nor unduly expensive, after a proper survey to lay out most villages with proper drains and banks to stop erosion and prevent water-logging of the low areas, providing suitable roads, footpaths and proper irrigation channels. At Kalianpur indeed it was found possible to make the channels serve the double purpose of catch drains and irrigation channels. Under present conditions, however, it is impossible to carry out alterations of this kind unless the land is the property of Government or, in rare cases, of a single individual.

Finally, in the case of one crop at least, the present lay-out of the average village hampers economic development and prevents the cultivator from getting a fair price for his produce. There are

many tracts in this province where the grower would willingly sell his sugarcane to a factory at prices more favourable to the factory than obtainable in most cane-growing countries. But the small scattered holdings often make the transport problem insuperable although sufficient cane is already grown within a reasonable radius and more would be grown if a factory could be started. As a result the cane grown is not economically utilized and extension of cane cultivation is checked. In the writer's opinion the present tenancy system has a great deal to do with the comparative shyness of capital for enterprises of this nature.

It is realized that drastic legislation such as would be necessary to permit of the re-striping of holdings requires a strong public opinion to support it, and it is, therefore, suggested that the first step would be to acquire a few villages in different parts of the Province, carry out the necessary alteration, and re-let the new holdings to the original tenants as nearly as possible. An object lesson of this kind would soon convince the land-owning classes of the need for general measures and, pending legislation, some of them might be able to assist in carrying out partial schemes in their own property.

If any excuse is needed for bringing before a science congress a matter of purely economic importance it seems sufficient to say that the existing land tenure system of this Province imposes a limiting factor on the application of scientific method to agricultural improvement.

SCIENTIFIC METHODS IN AGRICULTURAL EXPERIMENTS.

BY

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HAVING had occasion recently to collate the results of a large number of field experiments conducted throughout India and having had some difficulty in drawing anything but vague general conclusions from them, it occurred to the writer that a plea for more scientific planning and execution of such experiments might not be out of place.

The Rothamsted experiments seem to have been taken perhaps too much as a model on which experiments in India should be planned rather than as supplying a basis of information to be utilized in devising experiments more particularly suited to Indian conditions.

The information provided by the Rothamsted experiments is of two kinds, relating, firstly, to the reaction of the Rothamsted soil, and of the crops grown there to different manurial applications, and, secondly, to the wider subject of field experiments generally.

Little need be said about the first of these aspects except as regards certain limitations to the direct application of the results to conditions other than those under which the experiments were tried.

These results have proved that the application of manures containing nitrogen and the elements found in plant ashes, in quantities of the order of magnitude in which these elements are removed in crops, has a marked influence direct or indirect on the production of crops.

They have shown also that by a continued application of a manure complete in all but one of the important ash elements, the productive capacity even of land that contains enormous reserves of that one element may, by the removal of the crops grown, be reduced, in a comparatively small number of years, to very much below normal. And they have shown how rapidly nitrogen may be accumulated by the growth of leguminous crops, provided that a moderate supply of these ash elements in a soluble condition is maintained.

But while a foundation for local investigations has thus been provided, in the principle of supplementing the weakest links in the chain of chemical elements on which fertility depends, by a supply of the deficient elements in a soluble form, no attempt has been made at Rothamsted even to illustrate by local example, the solution of what must always be a local economic problem—that of adapting agricultural practice so as economically to extract from the insoluble reserves in the soil, and maintain in a relatively available form, sufficient proportions of the principal elements required by crops.

The cropping of Rothamsted has been purposely exhaustive, and manures have been freely supplied from outside; no attempt has been made to make the most economical use of the reserves of plant food existing in the soil, the full utilization of which must always be, in greater or less degree, an object of agricultural practice.

The importance of this point is shown by the rapidity with which the available potash was exhausted at Rothamsted, on a plot which received a manure containing all the other essential elements of plant food; and this, although the soil when completely broken down by hydrofluoric acid, was found to contain over 2½ per cent. of potash. Mr. Taylor at Sabour has similarly found over 6 per cent. of potash (over 8 tons, per inch depth, per acre) in a soil from Ranchi—where, nevertheless, ashes form one of the chief manures.

Now India is a poor country, and cultivators cannot afford to import over the long distances into the interior, any great quantity of heavy manures; or to use, as manure, what might otherwise be

fed to cattle ; while on the other hand the relatively rapid weathering and denudation due to climatic extremes brings within reach of the surface every year, a relatively large quantity of fresh subsoil for exploitation by plants.

Looking through a large number of experiments it appears that while much labour has been spent on testing the commoner commercial manures, comparatively little has been spent on attempting to get the most out of the soil by particular study of its constitution and reaction to special treatment.

Moreover the special value of leguminous crops as subjects for experiment under the conditions just described, hardly seems to have been taken into account in designing experiments in India.

Another limitation, and possibly a very important one, to the utility of the particular results obtained at Rothamsted in designing experiments in India, is the fact that chlorine and sulphur are supplied in excess of the demands of crops at Rothamsted by rain ; owing perhaps to the comparative proximity of the sea, and to the large consumption of coal in England, and to the even distribution of the rainfall. The writer is not aware of any published figures relating to this point in India, but recent experience at Ranchi of the very remarkable effect of small quantities (10 to 40 lb. per acre) of sulphur, and of gypsum, on groundnuts, indicates that sulphur at any rate may sometimes be a limiting factor on high-lying well drained soils in Peninsular India which are subject to leaching by heavy rainfall. Under such circumstances the use of sulphur or of gypsum on control plots, in experiments with sulphate of ammonia or superphosphate, is essential if reliable information is to be obtained.

But the intention of this paper is not so much to point out particular differences between English and Indian manurial problems as to indicate the necessity for independent scientific surveys of local requirements before planning experiments, and to suggest that the use of the classical experiments at Rothamsted to investigators elsewhere, lies rather in the lessons that have been drawn from them as regards agricultural experimental methods in

general than in the direct application of the methods employed there.

From this point of view the value of the Rothamsted experiments lies in the number and reliability of the statistics obtained.

Examined in the light of statistical science these figures have demonstrated the very considerable magnitude of the 'experimental error' in field experiments conducted under the most favourable conditions; and, though it is now some years since this was pointed out, there is little evidence that the lesson has been taken to heart in laying out field experiments in India.

Hall in an article in the *Journal of the Board of Agriculture* in August 1909, quoted an instance of the yield of two unmanured grass plots one of which gave, on the average of 50 years results, 10 per cent. more than the other; but frequently gave over 30 per cent., and on one occasion 96 per cent. more; and on two occasions over 20 per cent. less.

In a subsequent paper in the *Journal of Agricultural Science*, October 1911, Hall and Mercer showed that the most careful methods of growing, harvesting and weighing plots of mangolds and wheat, under apparently uniform conditions, gave results that were subject to 'probable errors' sufficiently great to make comparisons of the results from a single pair of plots worthless for most purposes. They recommended that for practical purposes in any field experiment each unit of comparison should be given five plots of one-fortieth of an acre each, systematically distributed within the experimental area.

The authors attached considerable value to the scattering of plots throughout the area and showed that the shape of the plots had (as indeed would be expected) in itself, no appreciable effect in reducing the error. But in an appendix to their paper, one who signed himself 'Student' showed how considerably the error could be reduced by having the plots for comparison relatively long, narrow, and alongside one another. By dividing squares into pairs of plots for comparison, less than two-thirds of the area was required to obtain the same accuracy as by random comparison in the case of roots, and in the case of wheat, less than half.

These results, depending chiefly on avoidable or unavoidable physical differences between the plots, are, of course, not quantitatively applicable to conditions other than those under which they were obtained. But the principle is of greater importance in proportion as the effective control of the experimental area is less, and is probably therefore more important under the conditions obtaining on most experimental farms in India than it is at Rothamsted where minor variations in the soil are less accentuated by extremes of rainfall or drought, and where the work was laid out on land carefully selected for uniformity in the light of a previous known history.

Yet on how many farms in India are even the five plots recommended by Hall and Mercer considered necessary for each comparison; and, where only two, or at most three plots are used, what results worth having can be obtained in the limited number of years over which a consistent policy can usually be maintained?

Acting on the principles that have been emphasized, the writer made an attempt during the last monsoon to throw some light on the manurial problems of Chota Nagpur, where immediate results were required to supply an existing organization with material for propaganda.

The conditions were unfavourable, the farm at Ranchi was started in May 1915, the land being then uncultivated. The best land that could be selected was not by any means uniform, as it was intersected by low terraces and was being carted over by building contractors. Inequalities had to be ignored; carting was stopped; and six acres were divided by low ridges at right angles into 60 plots, each 40 links wide by 250 long.

Analysis of the soil having shown a marked deficiency of lime and phosphoric acid, and only a trace of sulphur, it was decided to devote the whole 60 plots to quantitative tests of the effect on groundnuts of lime, sulphur, and bonemeal—the latter being used only because raw mineral phosphates were unobtainable owing to freight difficulties. The general scheme was based on the division of the area into series of plots for testing the different manures,

alone and in combination; test and control plots being alternated throughout. In comparing the results, the weight of produce of each variant plot was compared with the sum of the weights from the control plots on either side of it.

The details of the results, which will be published in the Farm report, are of no particular interest, except in the case of sulphur, to which reference has already been made.

The effect of sulphur was quite phenomenal and would have needed no duplication of plots for its detection, even when only 10 lb. per acre (costing 12 annas) was applied. Slaked lime, in all quantities up to 5,600 lb. per acre, was also markedly beneficial.

But the general character of the results is best illustrated by those given by bonemeal. This manure gave a markedly increased yield in each of 5 plots to which it was applied without lime, but when applied in addition to 4,000 lb. of slaked lime per acre it gave a relatively much smaller increase in 6 out of 7 plots, and this increase had again to be discounted by a decrease of 20 per cent. on the seventh plot—a discrepancy clearly due to 'experimental error,' of the importance of which in this case it gives some idea. If the number of plots had been much smaller, either the significance of the results might have been overlooked, or the discrepancies might have led to their rejection as inconclusive. As it is, conclusions have been drawn which, while showing weak points in the original plan of the experiments, have both enabled immediate recommendations to be made to cultivators, and have provided a solid basis on which to plan a new set of experiments for next year.

THE IMPORTANCE OF SOIL VENTILATION ON THE ALLUVIUM.

BY

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1. Introduction.

The dominant factor in the internal economy of the Indian Empire is the monsoon. The well-being of the people, the commerce of the country and the revenue collected by Government all depend on the amount and distribution of the summer rainfall. It is not surprising, therefore, to find that the attention of the agricultural investigator in India tends to be concentrated on questions relating to the supply of water to crops. At the same time, the other factors on which yield depends are apt to be obscured and crop-production comes to be regarded almost entirely as a question of water-supply. After ten years' observation of the crops grown on the Indo-Gangetic alluvium, during which a good deal of first-hand experience in agriculture has been obtained at Pusa in Bihar, at Lyallpur in the Punjab, and at Quetta in Baluchistan, the conclusion has been reached that a full supply of air in the soil is quite as important as a sufficiency of water. While air is a necessary raw material for the roots of plants wherever they may be grown, efficient soil ventilation is found in practice to be particularly difficult on alluvial soils like those met with over large areas of the plains of India. Alluvial soils, like those of the valleys of the Ganges and Indus, pack very readily and always run together on the surface after heavy rain forming a well-defined crust, well-known to any cultivator as the *papri*. Two chief factors are responsible for the ease with which

these soils form surface crusts after light showers and lose their porosity altogether after long continued rain. In the first place, the soil particles are small in size and exhibit no very great range in diameter and, in the second place, much of the rain comes in heavy continuous torrents quite unlike anything experienced in temperate regions.

Defective aeration of the soil, besides interfering with the respiration of the active cells of the root and of the soil bacteria, exercises a profound influence on the development of the root-system itself. Where the subsoil is wet and consolidated and gaseous interchange between the soil and the atmosphere has been checked, crops are found to develop superficial roots only and are then particularly liable to the harmful effects of drought. To withstand any shortage of moisture, to make the most of the brief growing season and to ripen the crop before the onset of the hot weather, the root-system of all *rabi* crops must be deep. In the *kharif*, long continued and heavy rain, by destroying the porosity of the soil and by thus interfering with the air supply to the roots and to the soil organisms, leads to a wilted, poverty-stricken condition of the crops and to a diminished yield. Such examples of damage to monsoon crops, caused by excessive rain interfering with aeration, were common in many parts of the United Provinces during the later phases of the 1915 monsoon.

II. Some Examples of Soil Ventilation.

Among the numerous instances observed of the effect of improved soil-ventilation on the growth of crops it will be sufficient to quote a few examples.

1. *The yellowing of peach trees.* As the summer progresses at Quetta, the foliage of many of the peach trees alters in colour and changes first to light-green and finally to yellow. Premature leaf-fall then takes place and, by the end of August, many of the branches are almost bare of leaves. In addition to the yellowing of the foliage, two other symptoms manifest themselves. The wood gives off large quantities of gum and the ripening fruit is deficient in flavour. Peach trees affected in this way die out in two or three

years, the process taking place in stages by the death of one or two large branches at a time. Investigation of the trouble showed that this unhealthy condition was not caused by want of available nitrogen in the soil and was not a real disease of the nature of the "peach yellows" of the United States. Buds taken from affected trees produced healthy plants and therefore the unhealthy condition was not transmitted in propagation. Yellowing was found to be reproduced at will, either by deep-planting or by over-irrigation. Any effective method of soil-aeration was found to transform affected trees into a healthy, vigorous condition in a single season. Yellowing and the premature death of the peach trees at Quetta was therefore found to be the result of defective aeration of the soil caused by excessive surface-flooding under arid conditions. The affected trees naturally carried a load of parasites such as scale insects and a certain number of fungi but with the resumption of healthy growth these pests gradually disappeared.

2. *Soil-aeration and green-manuring.* The provision of some cheap form of organic matter is one of the great needs of Indian agriculture at the present time. As is well known, the amount of manure available is small due to the fact that most of the cow-dung is burnt as fuel and almost all the *bhusa* is used for feeding cattle. As a rule, Indian soils are deficient in organic matter and the yield is limited by this factor. One theoretical method of making up the deficiency is by green-manuring but, in practice, difficulties arise. A considerable amount of attention has been paid to this subject in the Botanical Area at Pusa and the conditions necessary for the success of this operation have now been worked out. If a crop like *sanai* (*Crotalaria juncea*) is raised on the early monsoon rains and ploughed in during July, it is found that the texture of the soil is improved and, in a few cases on light land, the succeeding *rabi* crop benefits enormously by the addition of the organic matter left by the decay of the green crop. In the majority of Bihar soils, however, these results are not obtained and the *rabi* crops following green-manure are much worse than those raised on ordinary fallowed land. As a rule, green-manuring leads to a diminished *rabi* crop although the process results in the addition of a considerable

amount of organic matter to the soil. After some years' experiment, it was found that the factors on which success in green-manuring depends are connected with the air-supply in the soil. If the land is surface-drained and, if provision is made so that each field is protected from the run-off of other areas by a suitable arrangement of trenches, the effect of a green-manure crop is materially increased. If, in addition, the land is subsoiled to a depth of twelve inches before the *rabi* crops are sown, still better results are obtained. When broken tiles (*thikra*), at the rate of about 50 tons to the acre, are mixed with the upper six inches of soil, the results are exceedingly striking and a maximum crop can easily be obtained by green-manuring alone.

The simplest explanation of these results appears to be connected with the part played by air in the soil. The soil is usually regarded as a mass of small particles, arranged in various ways according to the degree of consolidation, with free spaces between these bodies known collectively as the pore-space. Surrounding the solid particles are films of water of various thicknesses while the rest of the pore-space is taken up by the soil-air. The proportion of the pore-space filled by water and air naturally varies with the general wetness or dryness of the soil. The closeness of packing of the solid particles varies greatly, after a crop is sown, as a result of consolidation by irrigation water or rain. In the water films round the particles, there is intense biological activity. Numerous bacteria are rapidly reproducing themselves while the root-hairs of the crop are competing with these soil organisms for water and inorganic food materials. All the protoplasm of these organisms is actively respiring and, in consequence, there is, in the water films round the particles, a keen struggle for oxygen and a great development of carbon dioxide. Under such circumstances, it is easy to understand how it is that analyses of the general soil-air often show a high proportion of carbon dioxide and a comparatively low percentage of oxygen. We must now consider what is likely to happen if this normal struggle for dissolved oxygen in the soil between the roots of the plant and the soil organisms is complicated by the sudden addition of a green crop like *sanai*. In the first place, the growth

of the green crop itself will naturally lead to a considerable pollution of the soil atmosphere by carbon dioxide. As soon as it is ploughed in, decay begins and an enormous quantity of oxygen is used up in the process which is by no means complete when the sowing time of a *rabi* crop comes round. The partly decayed organic matter adds a new competitor in the struggle for oxygen. It is easy to understand how the remains of the green crop might easily use up the oxygen in the pore-spaces and load the soil atmosphere with carbon dioxide to such an extent as to poison the air dissolved in the water films. Oxygen starvation and carbonic acid poisoning would affect the plant and growth would be checked. If we improve the aeration by drainage and by adding *thikra,* the decay of the green crop would be hastened and the air-supply of the soil during the succeeding *rabi* crop would be increased to such an extent that oxygen would no longer be a limiting factor.

The nodules of leguminous plants. The copious aeration of the soil in which leguminous crops are grown is perhaps more important than in any other class of cultivated plants. These crops require nitrogen for their nodules as well as oxygen for the respiration of the roots themselves. Once these facts are realized, it is easy to understand the distribution of leguminous crops in India and the agricultural processes in vogue in their cultivation.

The distribution of the gram crop closely follows the occurrence of well-aerated soils. It is only grown under irrigation where the soil is particularly porous or where there is a well-drained and well-aerated subsoil as occurs in many parts of the Bombay Presidency. If an attempt is made to grow this plant in stiff, heavy land, such as the low-lying loams of North Bihar, the result is disastrous. The plants only form roots near the surface and hardly any nodules are produced. The yield is scarcely more than the seed sown. Similar results are obtained under canal irrigation in the stiff loams in the Canal Colonies of the Punjab and other tracts of India. Heavy rains during the cold weather often destroy this crop simply by forming impervious surface-crusts and cutting off the supply of air to the nodules and roots.

In the growth of *rahar* (*Cajanus indicus*) in those tracts of India where the monsoon rainfall is heavy, the best results are obtained by digging the soil between the plants after the monsoon. Heavy rains consolidate the fine alluvium and the digging is necessary to restore aeration. In a similar manner, the Java indigo crop will only form seed in Bihar when the copious aeration of the roots is provided for. The slightest interference with the air-supply soon makes itself manifest by leaf-fall and by the shedding of flowers without setting seed.

III. The Maturation of Crops.

Besides its influence on the actual growth of crops, the provision of an abundant air-supply appears to be bound up with the ripening processes and with the development of quality.

In the case of the wheat crop, the best grown samples are always produced in tracts like the Meerut Division of the United Provinces or on the black soils of Central India, where the soils are naturally highly porous. In Bihar, Oudh, and in parts of the Punjab, where the natural porosity is not so great, the grain is always much thinner in appearance particularly in years when the rainfall is heavy during the ripening period. Unless the wheat roots get plenty of air during the process of maturation, the sample is always relatively poor.

Anyone who has studied the peach tree and has attempted to grow this fruit to perfection must have been impressed by the difference in quality of the same variety when the peach is grown on soils a little heavier than the normal. As is well-known, the peach thrives best on open soils and is particularly sensitive to any form of water-logging. Some years ago, the Botanical Section at Pusa achieved a local reputation on account of the excellence of the peaches grown there. The varieties were only country kinds but they were grown on high land containing a fair proportion of broken tiles (*thikra*). The soil was thus highly porous and the roots obtained abundance of air. The quality of the fruit was excellent compared with the produce of similar trees on land close by a little heavier in texture which contained no *thikra*.

In the growth of vegetables and flowers, some of the soils of Lucknow are famous. The best produce is raised under irrigation on the highly-manured sands near the banks of the Gumti. The soils in themselves are poor but, when properly manured and watered, their porosity is so great that surface-flooding causes little or no damage to its texture. The roots of the vegetables and flowers thus obtain abundant air and grow to perfection. The vegetables have excellent taste while the flowers easily form a quantity of good seed. Here again the development of quality seems to be closely associated with soil-aeration.

A similar result is seen in tobacco growing in Bihar. The best tobacco is grown on high, light lands which have been manured with indigo *seeth*. The *mahajans* pay more for such produce and several of the indigo factories have a reputation for their tobacco. *Seeth* is undoubtedly a most efficient aerating agent and all the experience obtained at Pusa in the growth of the tobacco crop points to the supreme importance of soil-aeration in the ripening of this crop. Once more, quality appears to be closely bound up with the ventilation of the soil which again appears to be of supreme importance in the process of maturation.

THE DYEING VALUES OF SOME INDIGENOUS DYE-STUFFS.*

BY

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I.

Natural dye-stuffs are perhaps not as bad as they have come to be regarded since their displacement by coal-tar colours. India boasted of a comparatively well developed art of dyeing in the earliest stages of the historic period. The ancient Indian dyer could dye some very good colours with the help of colouring matters derived from the natural and mineral kingdoms. Some of these colours were fast in every sense of the word and answered all the requirements of the people for whom they were intended. This points to the possibility of valuable colouring matters lying unknown or forgotten in the forests and jungles of this country.

A large number of woods containing red and yellow colouring matters are still used even in Europe but all these are obtained from America. There are undoubtedly similar woods in this country but so far no systematic investigation seems to have been made.

If America can find a market for so many dye-stuff extracts made from woods and other natural products, surely we with our vast, varied, and plentiful natural resources ought to have little

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* Of the two papers printed here only the second was contributed to the Indian Science Congress. The first was published by the Board of Industries, United Provinces, before the Congress was held. It has, however, been reprinted here as the second paper is in continuation of it.

difficulty in finding out and placing on the market similar products.

This question is of special importance at the present moment. The stoppage of the supply of German dye-stuffs has caused grave inconvenience in all colour-using industries. If Indian dye-stuffs had not been entirely discarded the distress would not have been so acute. At least some part of the world's requirements would have been met by the dye-stuffs indigenous to this country.

Colouring matters are widely disseminated in the vegetable kingdom. Some one has said that any one who wishes to spin, dye and weave his own raw material at his own fireside need not go far afield for his colouring matters.

Such is indeed the case in a great many places where cottage industries still flourish. In Donegal, famous for its homespun tweeds, the colouring matters used are still mostly derived from lichens and roots. The colouring matters of Donegal possess great fastness and beauty and their methods of application are alike novel and interesting.

I visited Donegal in December 1909 and submitted to the Secretary of State for India a report on the subject of the cottage industries of the congested districts of Ireland. I have alluded in this report to the processes of dyeing used in Donegal.

The following investigation into the dyeing values of certain natural colouring matters still used by native dyers was undertaken under the orders of the Director of Industries, United Provinces.

The colouring matters were tried on wool and cotton by some of the more important methods of modern dyeing.

The methods employed were as follows :—

A. On Wool.

(*a*) Dyed in an infusion of the colouring matter without the addition of any chemical or assistant to the dye-bath.

(*b*) Dyed in an infusion of the colouring matter with the addition of 4 per cent. acetic acid.

(*c*) Dyed as in (*b*) and after-treated in the same bath with 2 per cent. potassium bichromate.

(*d*) Dyed in an infusion of the colouring matter on wool which had been previously mordanted with bichrome and oxalic acid.

(*e*) Dyed in an infusion of the colouring matter on wool which had been previously mordanted with aluminium sulphate and tartar.

B. ON COTTON.

The cotton was steeped overnight in a decoction of myrabolans, next morning it was taken out, squeezed and without washing worked in fresh baths containing the following :—

(*a*) Tartar emetic.

(*b*) Stannous chloride.

(*c*) Alum.

(*d*) Ferrous sulphate.

Generally speaking all the dye-stuffs described hereafter gave the most brilliant results on stannous chloride ; tartar emetic and alum coming after that. Ferrous sulphate, as might be expected, dyed grey to black shades.

The inquiry has so far been prosecuted in regard to the following colouring matters :—

(1) HARSINGHAR. (*Nyctanthes Arbor-tristis*).

The flowers of this tree contain a beautiful yellow colouring matter. The tree is found in abundance in the United Provinces and when in bloom yields large numbers of flowers which generally open at night and fall to the ground in the morning. The flowers are collected, dried, and afterwards sold to dyers.

The colouring matter contained in the flowers is soluble in water, also in alcohol. An extract can therefore be easily made.

Harsinghar gives brilliant yellow shades with all mordants on wool. On wool mordanted with bichrome and oxalic acid previous to dyeing a beautiful brown is obtained. The dyeings on wool possess good fastness to milling with soap and soda.

(2) TUN. (*Cedrela Toona*).

This tree is said to occur largely in the sub-Himalayan forests. The colouring matter is contained in the flowers which are dried and sold. The principal constituent of the flowers is a yellow dye.

Tun dyes the best shade on wool in conjunction with mordant A(*d*). The dyeings on wool are, however, not very fast to milling with soap and soda.

(3) TESU OR DHAK. (*Butea frondosa*).

This tree is found in abundance all over the United Provinces. The dye extracted from the flowers is still largely used by villagers for sprinkling on their persons as a mark of festivity at Holi festival, about which time the tree is in full bloom. The dried flowers are, however, available throughout the year. The flowers contain a yellow colouring matter.

Tesu dyes on wool shades varying from brown to dull crimson according to the mordant used.

The dyeings are fairly fast to milling.

(4) HALDI OR TURMERIC. (*Curcuma longa*).

The plant which yields *haldi* is grown all over the United Provinces. *Haldi* is a dried rhizome or tuber and is a well-known constituent of curry powder. It is largely used as a spice and can be had in any quantity in the bazar. It contains a brilliant yellow colouring matter which however possesses the serious drawback of being changed into red by soap or by alkalis.

The colouring principle of *haldi* is called *curcumin*; it is sparingly soluble in cold water, more freely in hot water, and completely in alcohol. The use of turmeric paper in analytical chemistry is well known. Paper saturated with a solution of turmeric is changed to a reddish brown colour by alkalis; while its reaction with boric acid is still more characteristic. Turmeric paper on being moistened with boric acid and dried becomes brownish red which colour is changed to blue or green by caustic soda.

On wool the best shade is obtained on chrome mordant A(*d*). The fastness of the dyeings on wool is fair.

(5) ARUSA. (*Adhatoda vasica*).

The leaves of this plant yield a yellow colour. *Arusa* is an ever-green plant and is found in the United Provinces. The

colouring matter in *arusa* is soluble in water and also in alcohol. The leaves contain a large amount of chlorophyl which is extracted along with the yellow colouring matter. The chlorophyl considerably dulls the dyeings obtained with *arusa*. The yellow dye was separated by adding water to an alcoholic extract of the leaves. The chlorophyl was thereby thrown out of solution and the yellow colouring principle was obtained in the filtrate. This gave much better results in dyeing. On wool the best shade is obtained on chrome mordant A(*d*). The fastness of the dyeings on wool is fair.

(6) NASPAL OR POMEGRANATE RIND. (*Punica granatum*).

This plant is well known for its fruit. The rind of the fruit contains a tanning substance and also a yellow colouring matter, the latter in much smaller quantity than the former.

Pomegranate rind dyes very good shades varying from yellow to full brown on wool. All these possess very good fastness to milling.

(7) JANGLI NIL OR WILD INDIGO. (*Tephrosia purpurea*).

This is a small woody annual occurring in abundance in the United Provinces. It does not contain any substance yielding indigo and its name " Jangli Nil " is probably due to its similarity to the indigo plant.

Clarke and Banerjee have examined the constituents of the leaves of this plant. They found in it a colouring principle allied to quercetin or quercitrin (vide *Trans. Chem. Soc.* 1910, V. 97). Owing to the difficulty of separating the yellow principle from the chlorophyl, efforts to obtain a pure yellow from *Tephrosia* have only been partly successful. The colouring matter is, however, of great value, as it yields dyeings which are comparatively fast to light, washing, and milling. The yellow principle was separated by extracting the dry leaves with alcohol, diluting the extract with water, and washing away the chlorophyl with petrol. The purified colouring matter gave excellent shades of yellow in conjunction with various mordants. On account of the abundance of the plant it may be worth while devising a suitable process for extracting

the yellow colouring principle. It would no doubt be very welcome wherever fustic and quercitron bark are still in use. A decoction of the leaves of *Tephrosia* dyes wool mostly dull brown shades in conjunction with the various mordants, the most brilliant shade being that on tin mordant. The dyeings, however, possess very good fastness to milling.

(8) SAFFLOWER OR KUSUM. (*Carthamus tinctorius*).

The dried flowers of safflower plant contain a colouring matter which before the introduction of coal-tar colours was highly prized all over the world. It produces on cotton beautiful shades of red varying from a full crimson to the most delicate pink. Safflower is rather an interesting material. It contains two distinct colouring matters, viz. (1) a yellow soluble in water which is by far the larger constituent, and (2) a red which only occurs in small quantities but is, nevertheless, the more valuable of the two. The separation of the two colouring matters is thus effected. The florets are macerated with water which extracts the yellow colouring matter. When the maceration is complete and yellow colouring matter is no longer extracted, the florets are mixed with a dilute solution of carbonate of soda (*sajji matti*) which extracts the pink colouring matter. The cotton is worked in this solution in the cold for a short time. The bath is then acidulated with tartaric acid and the cotton worked in it for a short while whereby the pink colour makes its appearance. Native dyers use lemon juice for acidulating. The action is similar to that of tartaric acid. Silk may be dyed similarly but safflower is not suited to dyeing wool.

Although the yellow colouring matter in safflower is generally regarded as useless, Hubner has shown that certain mummy cloths which he examined had been dyed with safflower yellow (vide *Journal of the Manchester School of Technology*, Vol. 3, page 359). He found that these cloths contained appreciable amounts of magnesium sulphate, and his experiments proved that an addition of magnesium sulphate helped cotton previously mordanted with iron to take up the yellow dye pretty well and the shades obtained were similar to those of the mummy cloths. The Egyptians

were therefore acquainted with the right way of using safflower yellow.

Strange as it may appear, safflower yellow does not dye cotton in conjunction with aluminium and tin mordants.

Wool, however, possesses affinity for the yellow colour and may be dyed direct.

(9) MAJITH. (*Rubia cordifolia*).

The root and twigs of this plant contain a dye-stuff identical with madder. *Majith* was largely used in this country before the advent of synthetic alizarine. Its cultivation has now, it seems, entirely gone out. It is at present greatly in demand all over India, but enquiries made so far have shown that it cannot be had in quantities large enough to meet the demand for it. It is undoubtedly one of the most valuable indigenous dye-stuffs. With its help red, maroon, and bordeaux shades of excellent fastness to light can be dyed on all fibres. It is the basis of a great many colours required by the calico-printers. The Farrukhabad calico-printers were at one time large users of this dye-stuff and would be glad to go back to it if supplies were forthcoming. *Majith*, as might be expected, dyes very fast shades on both wool and cotton. The best results on cotton are obtained by using the Turkey Red process.

(10) CUTCH OR KATHA. (*Acacia catechu*).

The catechu tree is found in several parts of India. An extract made by boiling the wood in water is still largely used in dyeing. Catechu is exported to Europe for use in dyeing and tanning. Catechu may be applied to all fibres, though it is most largely used for dyeing cotton. The usual method of dyeing cotton consists in boiling the goods with an extract of catechu with the addition of copper sulphate, the weight of the copper salt being 10 per cent. of the weight of the colouring matter. The goods are squeezed, allowed to stand for a short time, and then boiled in a fresh hot bath containing 2 per cent. bichromate of potash, washed and dried. Catechu brown is one of the fastest colours known.

(11) Patang or Sappan Wood.—(*Cæsalpinia sappan*).

This tree is said to grow abundantly in Cuttack and in Central India. It is a variety of the so-called Brazil wood which was once upon a time very largely used in dyeing in Europe. The colouring principle, *brazilein*, exists in a colourless condition in the freshly cut wood and is by oxidation converted into the true colouring matter *brazilein*. The wood is similar in its composition to logwood. The oxidation of the colouring matter is carried out by a process of "ageing" in exactly the same way as logwood.

Patang is a valuable colour-yielding material. It can be used for producing brilliant shades of red, crimson, and purple and is very suitable for calico-printing.

(12) Lac dye.

This substance is of animal origin. It is the product of a small insect called *Coccus lacca* which lives on the twigs of certain trees such as *peepul* and *ber*. The incrustation produced by these insects on the twigs of the trees consists of (1) resinous matter, (2) colouring matter. The colouring matter is dissolved out by means of water or a weak alkali, the resin being left behind. The latter on melting and straining through canvas cloth constitutes *shellac*. The colouring matter is precipitated from its solution by means of alum and is afterwards pressed into cakes and sent out either for export or for sale locally.

Lac dye is manufactured largely in these provinces, though like other natural products it has lost much of its former importance Lac dye is dyed on wool, chiefly on tin mordant. It yields beautiful scarlet and crimson shades.

(13) Indigo.

A description of this is perhaps unnecessary here. Its use and importance are too well known to be drawn attention to in this paper.

Conclusion.

In the scope of this report it has been only possible to allude briefly to the dyeing values and properties of the various colouring

matters examined. Exhaustive trials have already been made with all the above dye-stuffs in conjunction with various mordants on both wool and cotton. The dyeings obtained in each case have been tested for fastness to light, washing, and milling. All these samples are being shown at the Exhibition of German and Austrian Goods now open at the Upper India Chamber of Commerce, Cawnpore.

These samples have already attracted the attention of users of dye-stuffs who have visited the exhibition, and enquiries respecting them have been received from one or two places.

Surprising as it may appear at first sight, India's natural resources are capable of supplying dye-stuffs required for producing any colour.

The thirteen dye-stuffs described above will enable a clever dyer to produce almost any colour.

We have in the list dye-stuffs yielding yellows, olives, browns, khakis, slates, greys, blacks, reds, scarlets, pinks, and blues. Suitable combinations of these colours will give us almost any shade.

The fastness of many of these dye-stuffs is not so bad as one is often led to believe.

It must, however, be admitted that most of these dye-stuffs are not available to-day in large quantities and the prices are consequently prohibitive.

Haldi, *cutch*, safflower, lac dye, and indigo are commercial products and may be had in fairly large quantities. *Tun*, *tesu*, *arusa*, and *Tephrosia* occur wild and arrangements may easily be made for collecting them. *Harsinghar* and *naspal* are not exactly wild products and so their collection will necessitate special arrangements being made.

Majith and sappanwood are perhaps the most difficult to get at and so far as we have been able to gather their cultivation has practically gone out, but an enquiry into the matter is still proceeding.

A systematic study of the properties and methods of application of these dye-stuffs would no doubt bring to light many valuable facts which would make the dye-stuffs more popular with the dyer.

There is every likelihood of a great many more colouring matters being found in the forests of India but this would be a matter for the Forest Department to deal with.

II

The examination of indigenous dye materials has been continued in the Technical Laboratory at Cawnpore. A communication on this subject has already been made to Government. Since then some additional dye materials have been examined and the following is a brief account of their properties and methods of application in dyeing.

(1) KACHNAR—(*Bauhinia racemosa*).

This is a shrub very common in these provinces. The bark yields a red dye which is largely associated with tannin. The dye is not very bright but nevertheless it may be employed for dyeing dull reds on cotton. It may be dyed on cotton without the help of any mordant. Cotton seems to have an affinity for it. Faster results are obtained on alumina or tin mordant. *Kachnar* bark is said to be used in Burma for obtaining a dull black colour on cotton. For this purpose the cotton is dyed direct in an infusion of the bark and is then worked in mud whereby the dull red colour is changed into a black (*vide* note by the Conservator of Forests, Eastern Circle, Burma, 1896). The bark can be had in any quantity, and may be of service to tent manufacturers who require a dull red colour for the inside of tents.

(2) PEEPUL—(*Ficus religiosa*).

The roots of this well-known plant were examined and found to contain a red dye which gives a good pink on cotton mordanted with alumina. The shade so obtained is fairly fast.

(3) RED SANDERSWOOD—(*Pterocarpus santalinus*).

This is a small tree occurring in Southern India. The wood yields a valuable red dye. It was largely used in dyeing before the advent of synthetic colours. The dye principle is called santalin. It was prepared in the laboratory in an impure state from an ethereal

infusion of the wood. The crystals deposited from the ethereal solution were further purified by washing them well with water, redissolving in alcohol, and precipitating with lead acetate. The precipitate was well washed with boiling alcohol and decomposed with sulphuric acid in the presence of alcohol, on removing the lead sulphate and concentrating the solution pure crystals of santalin were obtained. They melted at 103-105°C. (un-corr.)

Sanderswood dyes wool without any mordant. Very good shades of satisfactory fastness are obtained on cotton on tin and alumina mordants. The dye does not dissolve in water though it is freely soluble in alcohol, ether, and acetic acid.

(4) Roli or Kamela Powder—(*Mallotus philippinensis*).

This dye is obtained from a small tree found along the foot of the Himalayas and in Southern India. The fruits have red glands on the surface of the capsule and the powder is obtained by crushing or breaking up these glands. Kamela used to be largely employed for dyeing silk. It gives a beautiful yellow on silk mordanted with alumina. The shade obtained compares favourably with that dyed with chrysophenine. The dyeing must be done in an alkaline bath.

(5) Akhrot—(*Juglans regia*).

The bark yields a valuable brown dye. It is of special importance for wool at the present moment because it yields on this fibre a fast shade which may easily be modified to a khaki. A great many dye trials were made and as a result of these the following conclusions were arrived at :—

(*a*) The deepest shade is obtained by dyeing with an addition of 3 per cent. acetic acid to the dye-bath. The fastness to light is, however, poor in this case.

(*b*) Fairly full shades were obtained on chrome-oxalic acid mordant or by the after chroming process. Both these give dyeings of excellent fastness to light and milling. The poorest results both as regards

depth of shade and fastness to light and milling were obtained when the dyeing was carried out with an addition of 15 per cent. Glauber's salt to the dye-bath.

(6) KATHAL. (*Artocarpus integrifolia*).

The wood yields a yellow dye which may be dyed on cotton on alumina mordant. The shades obtained are good and fast.

(7) BARBERRY. (*Raswat*).

The bark, roots, and stem of this plant are rich in a very good yellow dye. This plant is plentiful in the Kumaun Hills. The aqueous infusion of the bark and stem is used as a medicine for ophthalmia and is highly prized as such. The dye principle of barberry is berberine which is an alkaloid containing nitrogen. Berberine was prepared in a state of purity from barberry by adding alcohol to the aqueous extract whereby all foreign matter was precipitated. On concentrating the filtrate crystals of barberine were obtained which were purified by recrystallisation from water.

Raswat is used chiefly as a dye for silk. It was dyed on cotton mordanted with alumina but dull shades were obtained. This was perhaps due to the presence of chlorophyl in the preparation which came from Naini Tal.

(8) *Rhus cotinus*.

The wood of this plant yields a dye similar to young Fustic. On cotton mordanted with alumina an orange yellow colour was obtained; with tin an orange red was obtained. The dyeings are, however, not fast to alkalis and soap.

THE AQUATIC WEEDS OF THE GODAVARI AND PRAVARA CANALS OF THE BOMBAY PRESIDENCY—A PROBLEM IN APPLIED ECOLOGY.

BY

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In 1915 the author was invited to examine and report on the weed growth in the Godavari and Pravara Canals of the Bombay Presidency, since this growth had in some places become so great as seriously to impede the flow of the water. The Godavari canals were accordingly examined from their pick-up weir at Madmeshwar lake to mile 31 on the Left Bank Canal and mile 49 on the Right Bank Canal. Similarly the Pravara Right Bank Canal was examined from its head-works for 18 miles. The Pravara Left Bank Canal, being still under construction, was not examined.

The weeds discovered were the following :—

(1) *Potamogeton perfoliatus*, Linn.

(2) *Potamogeton pectinatus*, Linn.

(3) *Vallisneria spiralis*, Linn.

(4) *Hydrilla verticillata*, Casp.

(5) *Naias* (?) species.

(6) An alga, resembling *Oedogonium*.

With the exception of the alga, the weeds mentioned are plants rooted in the soil, with their shoots rising into the water to various heights. *Potamogeton perfoliatus* (Plate VI), is the most serious pest, and the impeding of the flow in the canals is due to it. This plant has a creeping rhizome, two to four inches below ground, from the nodes of which slender adventitious roots penetrate deeper into the

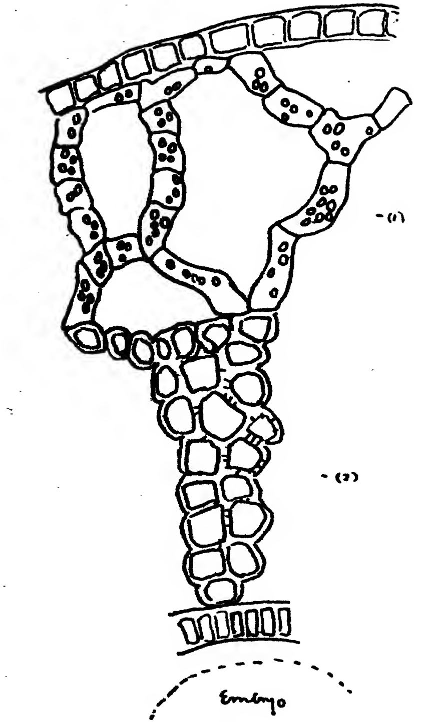


Fig. 1.

Transverse Section of Fruit coat of *Potamogeton perfoliatus*, showing (1) starch containing floating tissue, and (2) protective sclerenchymatous sheath.

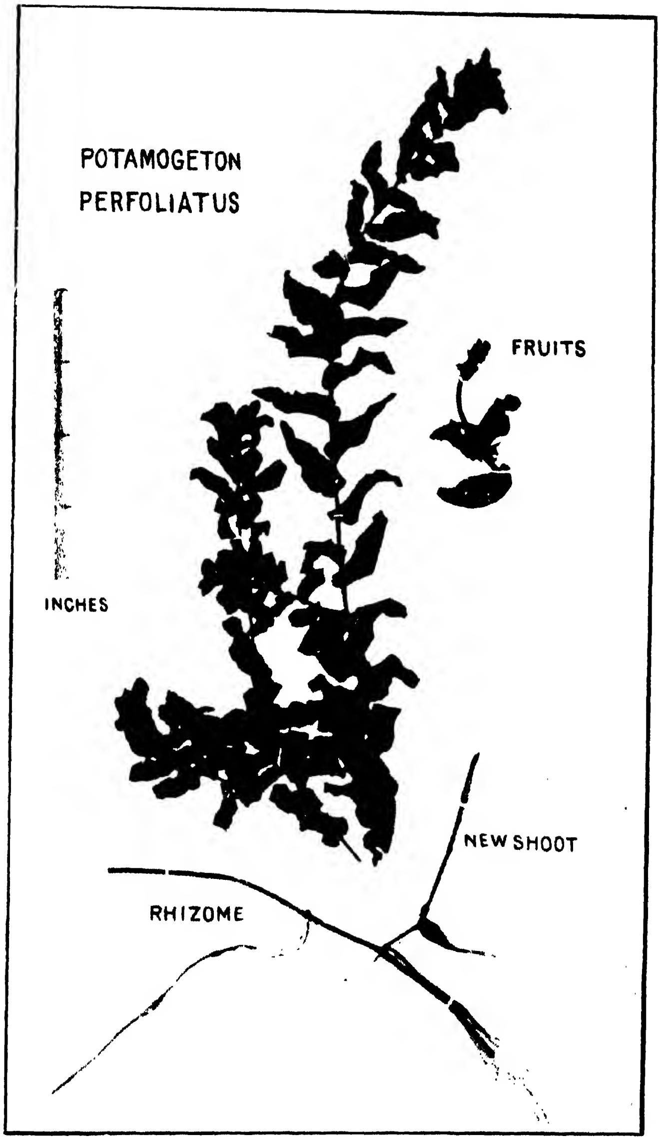
× 124.

Semi-diagrammatic.)

Fig. 2.

Plant of *Potamogeton pectinatus* 17 days after germination of resting tuber ; two ungerminated tubers attached. Natural size.

(Semi-diagrammatic.)



Potamogeton perfoliatus.

soil. The growth of this rhizome appears to be monopodial. The stems arising from its nodes may be of great length. One taken at random from Madmeshwar lake measured $12\frac{1}{2}$ feet from root to tip, the branches and leaves being confined to the top 2 feet. In the 49th mile of the Godavari Right Bank Canal, in water 10 feet deep, two stems taken at random measured 12 and 10 feet respectively with branches and leaves on the terminal $1\frac{1}{2}$ feet. It is unnecessary to give a detailed botanical description of the plant, but points of ecological interest must be considered. Among these, the reproduction of the plant is of the first importance. As already mentioned, the creeping stem forces its way through the soil, sending up new above-ground stems. Reproduction by fruits appears to take place freely. In the Madmeshwar lake many plants of *P. perfoliatus* were in flower or fruit. The small compact spikes stand about one inch above the water. The method[1] of pollination is by wind, and judging from the copious formation of fruits, conditions are favourable. Some of the fruits fall off from the spike and float for a time, and it may be that the whole spike also becomes detached, but this has not yet been observed by the writer. The fruits are 1 mm. × 2 mm. × 2 mm., ovate and pointed in shape, and very thick coated. Fig. 1 shows a cross section of such a fruit with floating and protective tissues. The length of time that these fruits float and the factors affecting it have not yet been determined. This point is important, especially in the present case, where the regulators of the pick-up weir are so arranged as to draw off the surface water only.

It is probable that the Godavari canals have been infected from the Madmeshwar lake by the drifting down of these floating fruits. Leaving this point for the moment let us see if there is any discoverable reason for the extraordinary prevalence of *Potamogeton perfoliatus* in the said lake. The weir which is the cause of the formation of the lake was completed a few years ago. After its completion, a considerable area of previously dry land was submerged and one village had to be vacated. In the first year after the

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[1] Knuth, *Handbook of Flower Pollination* (Answorth Davies), vol. III, p. 507.

completion of the weir no weeds were observed in the lake. The exact date of their appearance is doubtful. It is possible that fruits of *Potamogeton perfoliatus* from plants in higher pools of the Godavari drifted down into the lake. The newly submerged land would be, as far as aquatic plants were concerned, *a denuded area*, and invasion would be easy. It is interesting to note that the portions of the lake occupied by weeds correspond roughly to the recently submerged areas, while the beds of the Godavari and Kadwa rivers, running through the lake, are clear of weeds. At the same time there are clear patches of water close to weedy areas which cannot be thus easily accounted for. It may be that at such points the substratum is not suitable for the growth of the rhizome.

The freedom of the river beds from weeds is probably due to the greater depth, and possibly to the greater opacity of the water. The influence of the Godavari is felt more in the Right Bank Canal and, if the water reaching that canal is coming unusually directly from the river channel, then the water is more muddy and at the same time more free of floating fruits of *P. perfoliatus*. Such a direct flow appears to have occurred in 1915, weed growth in the Right Bank Canal having been considerably retarded during September and October, although other conditions appeared normal.

The weed grows in water from 1 foot to 20 feet deep. This latter figure is not the maximum depth at which it can grow, but is merely a deep sounding taken casually in a weed area in the Madmeshwar lake. Scott Elliot[1] reports *Potamogeton* at 26 feet in Bruyant, France.

Variations of turbidity or velocity of water seem to have little effect on the distribution of the weed. The leaves occurring on the last 2 feet of the stem are always just below the surface and hence get plenty of light even if the water be muddy. The weed was found in water of all velocities from zero to 4 feet per second and thrives equally well in them all.

It is a curious circumstance that the weed occurred also here and there in borrow-pits beside the canal but having no direct

[1] Scott Elliot, *Modern Botany* (1910), p. 132.

connection therewith. There are three possible explanations of the infection of these borrow pits. The fruits may have been carried (1) on the feet and feathers or in the stomachs of aquatic birds, or (2) in mud on the feet of cattle, or (3) they may have come from bunches of the weed piled on the banks at the time of cleaning of the canals. The fruits may then have been washed or blown down into the pits.

Complete closure of the canal for a prolonged period would doubtless kill the weed, but there is so much land under perennial irrigation from the canal that a prolonged closure is impossible. A closure which is sufficient to kill the exposed stems does not affect the under-ground rhizomes, which begin growth when water is once again let down the canal.

The vegetative growth of the weed is considerable from November to February and is at its maximum during December and January, just after its fruiting period in November. During the hot weather the vegetative growth diminishes, and is more or less dormant during the rains. In this respect, this aquatic weed forms a remarkable contrast to most of the land vegetation of its neighbourhood.

It is possible that the fall in temperature during the rains is the factor that checks weed growth. The factor of extra silt and consequently greater opacity of the water must also be taken into account. Only experimental evidence, however, can determine which of these factors is the more important.

Any methods for controlling this weed must, as far as these observations go, aim at (1) the prevention of fruit formation in the Madmeshwar lake so as to avoid further infection of the canals; (2) the repeated cutting or dredging by suitable apparatus of the weed in the lake to prevent its further spread therein; (3) the extirpation of the rhizomes of the plants now established in the canal. Means to attain these three ends are being considered.

Of the other weeds, *Hydrilla, Naias* (?) and *Vallisneria* were found in Madmeshwar lake completely submerged and out of sight in 4 feet of water. None of them were in fruit. They occurred at various points in the canals but were not serious pests.

Potamogeton pectinatus was found in flower at three points in the canal. It was found also in the lake. On account of its linear leaves, it does not hold up the water in the same way as *Potamogeton perfoliatus*. *Potamogeton pectinatus* has peculiar vegetative reproductive bodies not mentioned by Hooker, Cooke, or Woodrow, but briefly referred to by Continental writers.[1] These bodies are small rhizomes consisting of closely packed tubers; each tuber having on one side a shoot ready to start into growth, and on the other a slender internode connecting it with the next tuber. Small chains of these tubers were found both floating in the water and buried in the soil of the canal. The author was absolutely ignorant of their relationships until he grew one experimentally and got from it an unmistakable plant of *Potamogeton pectinatus*. Fig. 2 on p. 66 shows the plant produced. The germinating of such resting-bodies at this season tallies with the cycle of growth already noticed in which the monsoon is the resting season for such aquatic plants.

In the Pravara Right Bank Canal the weeds were much fewer, and the head-works, which is comparatively small, showed only one specimen of *Potamogeton pectinatus* and no *Potamogeton perfoliatus*. The latter is, however, found in the canal and the infecting fruits doubtless come from higher up the river.

The whole question of the control of the weeds of these canals constitutes a most interesting problem in applied ecology.

ADDENDUM.

Since the above paper was written for the Indian Science Congress, further collection of weeds from the Madmeshwar lake, and observation of specimens grown in tubs have brought to light the fact that the floating stems have the power of producing rooted branches adventitiously. It is likely that these branches later on fall off or are detached by the decay of the parent branch. This discovery makes the task of eradication of the weeds even more

[1] Engler and Prantl, Natürlichen Pflanzenfamilien II Teil, I Abteiling p. 195 Handwörterbuch der naturwissenschaften, X Band, 519.

difficult since it will be necessary not only to prevent fruit formation, but to check the drifting down of these rooted and detached branches.

Fruits sown under water in November 1915, germinated in March 1916.

The artificial conditions in the tubs induced flowering after four months.

It appears also that there are probably three varieties of *Potamogeton perfoliatus* in the lake. Specimens of these are now being grown to determine if they are genetically distinct.

IRRITABILITY OF THE BLADDERS IN UTRICULARIA.

BY

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A SPECIES of *Utricularia* very near *flexuosa* is a free floating insectivorous plant (found in a tank in Madras). The leaves are finely dissected. The bladders that entrap insects hang by short stalks from the axes of the leaves (Plate VII, fig. 1). They are oval in shape and are broader in one direction than the other. The mouth of the bladder is horse-shoe shaped, with the bend of the horse-shoe posterior and the base anterior. The mouth is surrounded by a ridge which is produced at the two ends of the base of the horse-shoe into two stout projections from which branched hairs start. These hairs are referred to by Darwin as the antennæ. Except along the base of the horse-shoe the ridge is fringed with long pointed hairs (Plate VII, fig. 2, and Plate VIII, fig. 1).

The valve or trap-door of the bladder is attached to the inner and lower margin of the ridge all along the base of the horse-shoe and to a very short extent along the sides. In the living condition the valve is not flat as is commonly supposed but is transversely convex and dome-shaped when looked from above. The apex of the dome lies very near the bend of the horse-shoe so that the curve of the arch rises very gradually from the base up to very near the bend of the horse-shoe and then has a sharp fall (Plate VIII, fig. 2). From the apex of the dome start six or eight long pointed hairs arranged in two sets with a short space between. The hairs stretch towards the base projecting slightly upward and are nearly as long as the

PLATE VII

Fig. 1. *Utricularia* Sp., very near *U. flexuosa*.

Fig. 2. Single bladder enlarged. Horse-shoe shaped ridge or "collar" round the mouth, produced into two branched hairs called the "antennæ" and surrounded with simple hairs. The shaded portion on the valve near the base of the horse-shoe shows the position of a large number of secretory hairs. The six irritable hairs on the valve are seen pointing towards the antennæ.

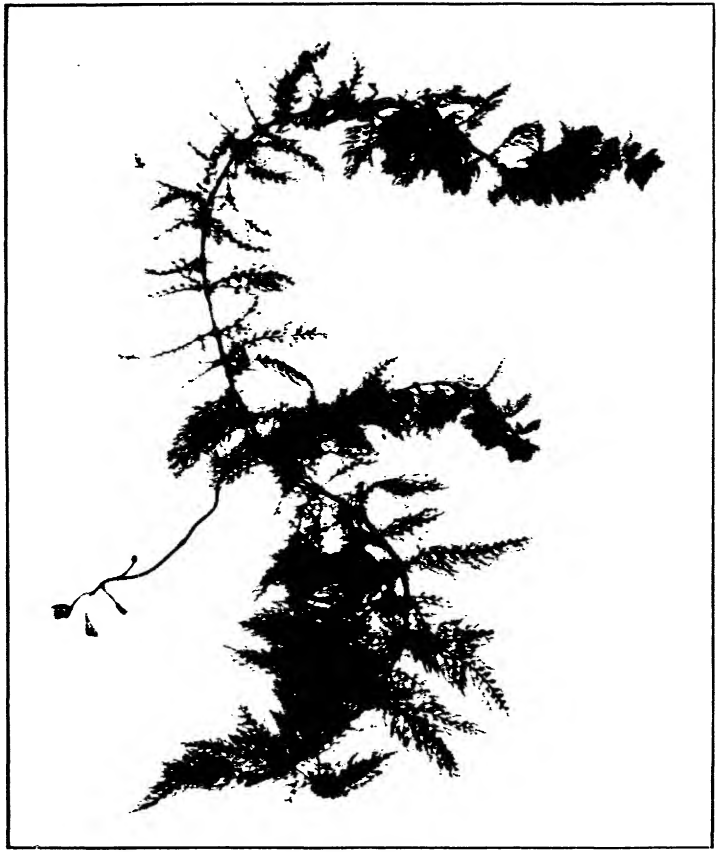


Fig. 1.

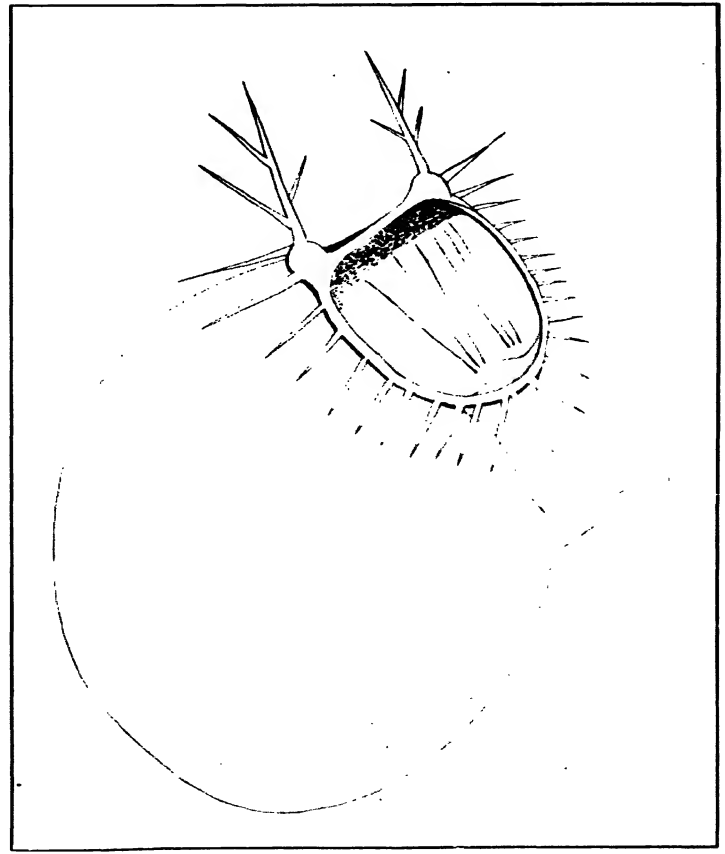


Fig. 2.

PLATE VIII.

Fig. 1. Surface view of the mouth with the valve. For explanation refer plate VII, fig. 2. The hairs surrounding the collar are omitted.

Fig. 2. Median longitudinal section, showing the mouth closed up by the valve. The free margin of the valve presses against the collar from below. The irritable hair is shown on the valve.

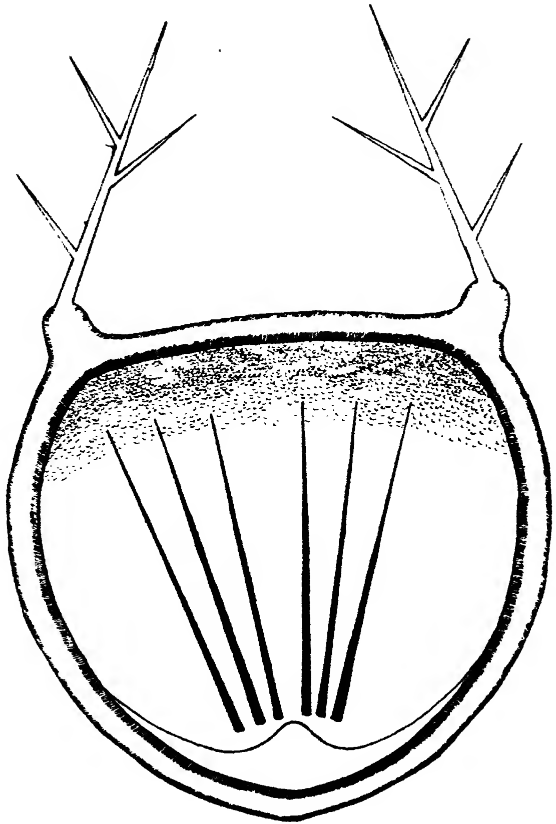


Fig. 1.

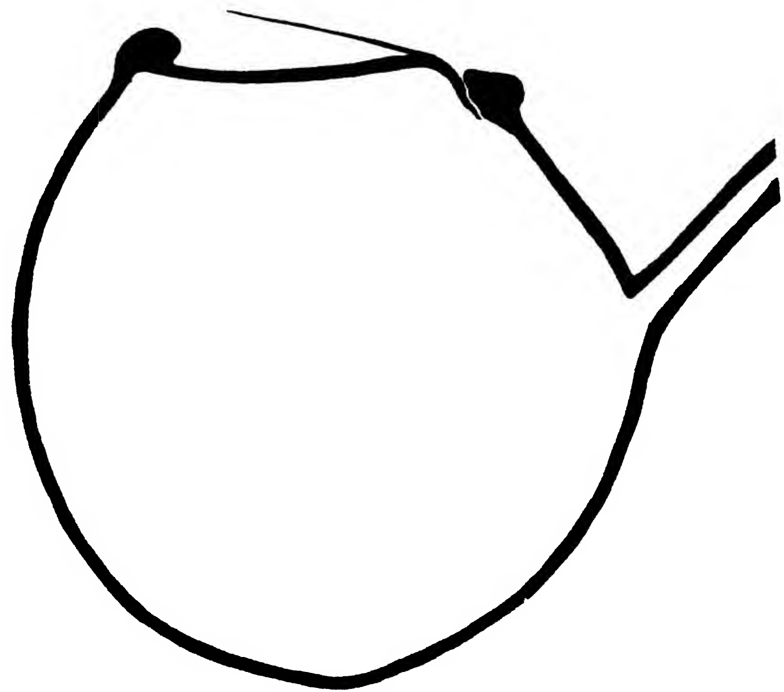


Fig. 2.

valve. The portion of the upper surface of the valve nearest the base of the mouth is densely clothed with club-shaped hairs which are glandular and secretory. The valve has a thin margin which goes below the ridge of the mouth all round and is tightly pressed against it.

Darwin has shown that small crustaceans and other animalculæ are found inside these bladders and that, since they cannot escape once they are caught, they die and decay. The decayed animal matter is absorbed by peculiar quadrifid hairs, found on the inner surfaces of the walls of the bladders.

My attention was drawn to a peculiar behaviour of this plant, when I was distributing specimens to my class for studying the structure of the bladders. As the specimens were lifted out of water to be placed in smaller dishes, they made light crackling sounds resembling the ticks of a watch. The sounds were unaccountable by anything I knew of the structure of the different parts of the plant. After a series of observations, they were located as coming from the bladders. The state of the bladders before and after lifting the plants out of water, gave the clue. When the plants had been allowed to remain quiet for two or three days in water, among the full grown bladders nearly 25 per cent. were found to be half filled with air and half with water. Nearly 50 per cent. were found to be completely filled with water and in some of these, the small organisms entrapped may be seen. The rest were nearly empty, with the walls closely adpressed against each other, so that there was very little cavity inside, and the bladder as a whole was biconcave.

The first two kinds of bladders with the walls convex and with the cavity inside filled with water or water and air, I will designate as "full." The last with its walls concave and with very little cavity, I will call "hungry." In every case the valve or trap-door was tightly pressed up against the rim of the mouth. When the plants were lifted up and replaced in water, there were very few hungry bladders left and in their places were now found some completely filled with water and others with water and air. There was no change in the full bladders. From this it

was inferred that the hungry bladders, when they were disturbed and came in contact probably with the leaf segments or other parts of the plant, opened out and let in water or water and air. Hence I suspected that the bladders were irritable and that the valve was very likely not simply a passive elastic door to be pushed in as Darwin supposed by an unwary or inquisitive animalcule, but an active trap-door which helped the bladder to forcibly suck in its prey.

As to the manner by which the animalcules make their way into the bladders, Darwin says " Animals enter the bladder by bending inwards the posterior free edge of the valve which from being highly elastic shuts again instantly. As the edge is extremely thin and fits closely against the edge of the collar, it would evidently be very difficult for the animal to get out when once imprisoned and apparently they never do escape. As I felt much difficulty in understanding how such minute and weak animals as are often captured, could force their way into the bladders, I tried many experiments to ascertain how this was effected. The free margin of the valve bends so easily that no resistance is felt when a needle or thin bristle is inserted. A thin human hair fixed to a handle and cut off so as to project barely $\frac{1}{4}$ of an inch entered with some difficulty, a longer piece yielded. On three occasions, minute particles of blue glass (so as to be easily distinguished) were placed on valves while under water and on trying gently to move them with a needle, they disappeared so suddenly, that not seeing what had happened, I thought I had flirted them off ; but on examining the bladders they were found safely enclosed. The same thing occurred to my son who placed little cubes of green boxwood on some walls and thrice in the act of placing them on or whilst gently moving them to another spot, the valve suddenly opened and they were engulfed. He then placed similar bits of wood on other valves and moved them about for some time and they did not enter." " To ascertain whether the valves were endowed with irritability, the surfaces of several were scratched with a needle or brushed with a fine camel-hair brush so as to imitate the crawling movements of small crustaceans, but the valve did not open. We may, therefore, conclude that the

animals enter merely by forcing their way through the slit-like orifice, their heads serving as a wedge." "But," says Darwin, "I am surprised that such small weak animals should be strong enough to act in this manner, seeing that it was difficult to push in one end of a bit of hair $\frac{1}{4}$ of an inch long." Darwin evidently came to the above conclusion quite half-heartedly and he missed the correct solution by a hair's breadth.

I will first corroborate Darwin's idea that it is unlikely that such small and weak animals should be strong enough to enter the bladders by pushing in the valve, and then try to explain the mystery of the particles of blue glass and boxwood. I tried to get an idea of the pressure the valve was able to withstand before it yielded and was pushed in. For this purpose, I used a spring which was fixed to a stand by one end. To its other end a piece of cork, with a small metal cup on its top and a needle stuck in at the bottom, was attached, so that the blunt end of the needle hung free. Below this was placed a Ziess's hand microtome which has a flat circular top, with a hole in the centre, through which the block-holder can be moved up and down by a micrometer screw. A bladder was cut across and the upper half, with the valve, was made to rest on its cut end, inside a narrow glass ring fixed to a slide. The ring was filled with water so that the cut bladder was immersed in water. The slide was placed on the microtome and slowly raised until the free end of the needle rested on the valve just touching it. Care was taken to see that the end of the needle did not come in contact with the ridge surrounding the mouth. The orifice was big enough to admit the end of the needle freely. Sand grains were now added to the metal cup until the lid just gave way. The weight of the sand grains which was 270 mg. gave an approximate idea of the pressure that the lid was able to withstand. This is likely not accurate, as here, the weight of the sand grains included not only the upward pressure of the valve, but also the weight necessary for the extension of the spring. To avoid it, as I thought, the action of the spring was reversed in this manner. The weight necessary for stretching the spring to a known distance was first calculated and then in the stretched

condition the needle was made to rest on the valve. Now the valve was gradually raised until it gave way. The distance to which the spring was raised to effect this, was made out and from it the weight supported by the valve was calculated. The weight thus got was 250 mg.

Now, let us consider the pressure the organisms can exert on the valve. Though it was not possible to get an accurate estimate, the following considerations, I expect, will give an approximate idea of the pushing force of the crustaceans and others, found inside the bladders. The force, that these organisms can exert, can be derived in three ways : firstly, their weight ; secondly, the momentum with which they dash against the valve ; and thirdly, the activity of their own muscles or any other structures corresponding to them.

The first factor, namely the weight, is quite negligible, since it will be greatly or fully counteracted by the buoyancy of water. As regards the second source, namely the momentum, the habit of these organisms, when they approach the bladders, is of great interest. I have spent a long time watching for the suction of the animals into the bladders. Whenever an animal approached a bladder, its quick motion was stopped and it went round as if it were brousing along in search of food and in no case was there an aimless or unwitting impact with the valve. Darwin says " It is difficult to conjecture what can attract so many creatures, animal and vegetable feeding crustaceans, worms, and various larvæ to enter the bladders. Perhaps small aquatic animals habitually enter very small crevices like that between the collar and the valve, in search of food or protection." My observations lead me to believe, though I am not yet in a position to prove definitely, that the attraction for these animals lies in the secretion of the clubheaded hairs found profusely near the base of the horse-shoe on the valve. Since the animals when they are near the bladder move about very slowly, the second source of energy is also not of any consequence. The third source, that of muscular power, is hard to get at and can only be guessed ; but a different consideration will, I think, put this source out of court. The distribution and direction of the long-pointed hairs round the ridge are such that entrance into the horse-shoe is

easy only through an arch formed by the antennæ or the very long branched hairs at the base of the horse-shoe. Now if an animal enters through this arch, it will necessarily come against the sharp points of the hairs which stretch from the apex of the valve towards this entrance. So it appears impossible for the animal to get at the edge of the valve and push it in. The above considerations, I hope, show that the presence of the animals inside the bladders cannot be due to their pushing their way in.

To see whether the suspicion that the bladders were irritable had any basis, the following experiments were done. First I selected some of the "hungry" bladders and irritated with a needle the different parts of the ridge, round the mouth and the valve. When the hairs at the apex of the dome of the valve were irritated, the adpressed sides shot out suddenly with a sharp explosive sound and the bladder got filled with water or air. I repeated this over and over again, so as to assure myself that I did not really push the valve in, but only irritated the hairs, and in the case of every hungry bladder the same reaction followed. No reaction occurred when any other parts of the region were irritated, so that I was able to assure myself that these particular hairs were the irritable hairs. Then I wanted to see whether similar conditions obtained when an animal was caught inside the bladder. It was found impossible to manœuvre the organisms to the bladders and, though I observed for a long time, I was not able to see an organism actually sucked in. But the critical question, whether a bladder is capable of sucking in the organisms if they irritate the hairs on the valve, was settled by another means. Once a dead fly, more or less in a putrifying condition, was found floating on the water in one of the dishes. I took the front half of the fly at the tip of a needle and irritated the hairs of a hungry bladder with the head of the fly. To my joy, the whole object was immediately sucked in. This set at rest my doubts as regards the capacity of the bladders to suck the organisms in, as the biggest of the crustaceans found inside were not more than $\frac{1}{3}$ of the head of the fly in size.

I wish to draw attention to the fact that the above experiments were done with the hungry bladders only. The full bladders

do not react to irritation. This explains the mystery of the disappearance of the particles of blue glass and boxwood in some cases and not in others. I take it that the bladders that swallowed the particles were 'hungry' and those that did not were 'full.' The same fact also explains the negative results obtained by Darwin when he irritated the bladders, as nearly 75 per cent. of the bladders in a plant are in the 'full' condition and the 'hungry' bladders are generally very few. It may also be due to the fact that the reaction to irritation is extremely quick and easily escapes notice.

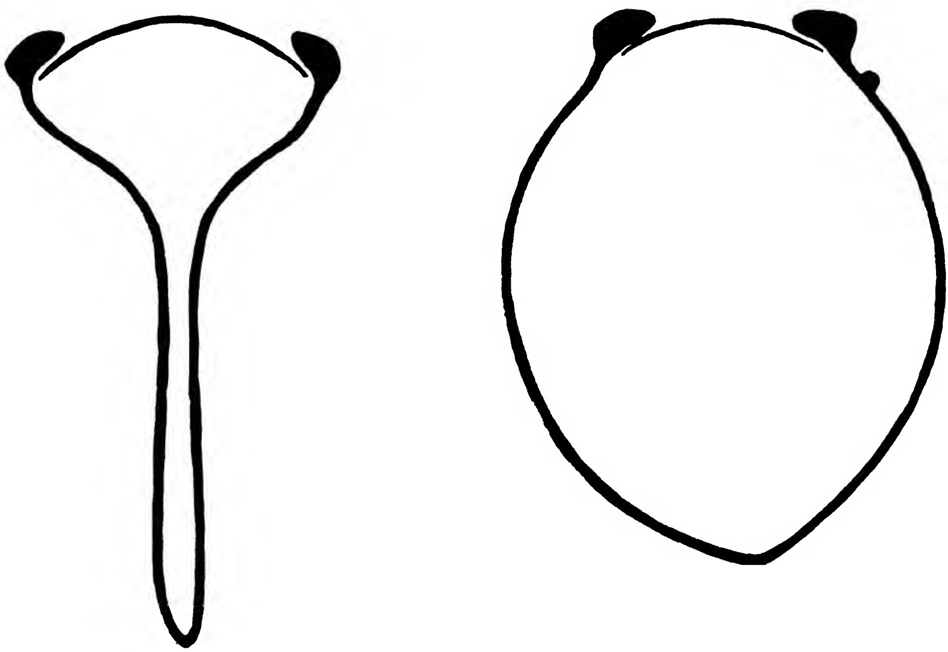
A few words about the mode of action under irritation. Owing to the quickness of reaction, it is impossible to observe directly the opening and closing of the valve. When the valve of a full or non-hungry bladder is pressed down with a needle as far as it could go, the irritable hairs project right in the centre of the opening. If an animal is sucked in when the valve is in this position, it should be either impaled on the hairs or the hairs should be broken. But I could never believe, that in such a delicate mechanism, this flaw could ever occur. The explanation was arrived at rather accidentally. In an idle mood I pressed out the contents of a full bladder with a pair of pincers. The contents came out through a slit formed by a portion of the margin of the valve being pushed out. When the pressure was relieved, the valve fell back quickly to its place and no water entered from outside ; but some air escaped from the intercellular spaces in the walls of the bladder and filled up the cavity. Then, I once again pressed out all the air and over again when more air came in. When the air was driven out twice or thrice, the bladder assumed the hungry condition. When I irritated the hairs, it reacted in the normal manner. I got very much interested and the whole operation was thrice repeated with the same bladder. The valve went in once again under irritation but never came back and the bladder was left wide open. When I looked through the open mouth, I could not see the irritable hairs and the passage was perfectly clear. It was then that the proper position of the irritable hairs, when reacting to irritation, was shown. On examination, it was found that the convex valve had become concave and boat-shaped, and the hairs were found safely

PLATE IX

Fig. 1. Longitudinal section at right angles to the plane in plate II, fig. 2. The left-hand diagram shows the "hungry" condition with the walls concave and adpressed. The right-hand one shows the "full" condition with the walls

Fig. 2. Median longitudinal section, showing the position of the valve when the bladder opens under irritation. The valve is concave and drawn back and has the irritable hairs laid in the hollow.

PLATE IX.



a Fig. 1 b

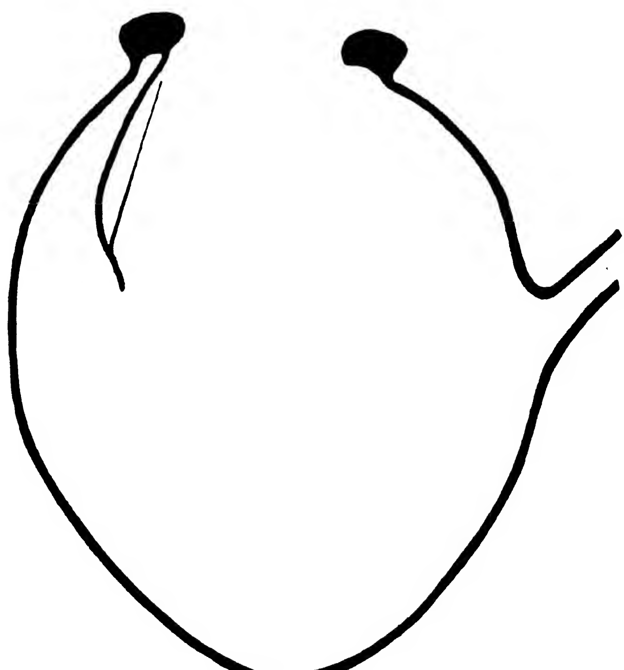


Fig. 2.

laid at the bottom of the boat. The orifice was fully open without any obstruction. (Plate IX, fig. 2.)

The nature and arrangement of the cells that go to make up the valve, the irritable hairs, and the ridge are very interesting. Their relation to the functions performed is under investigation.

MODELS TO ILLUSTRATE SEGREGATION AND COMBINATION OF MENDELIAN CHARACTERS.

BY

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It is not proposed in this paper to expound the principles of heredity discovered by Mendel. My object is merely to explain the working of models devised by me to demonstrate the behaviour of hereditary characters that conform with Mendel's principles, as they are transmitted from one generation to another.

I have taken glass beads to represent the determiners of hereditary unit characters. A coloured bead is used to represent the determiner of a dominant character. A colourless bead of the same shape and size is used to stand for the corresponding recessive, if the presence and absence hypothesis of dominant and recessive characters is to be illustrated. A certain modification of the entire model is devised to illustrate the working of the determiners of heredity, when the recessive ones are supposed to have a definite existence.

I have represented the idea of there being two determiners or a double dose of a dominant character in an individual by taking two coloured beads which are in every way identical. The single dose condition is represented by two beads of the shape and size but only one of them is coloured while the other is colourless. The nil dose or recessive condition is represented by two uncoloured beads. The use of any beads whatever to represent recessive determiners when they are conceived to have no existence at all is

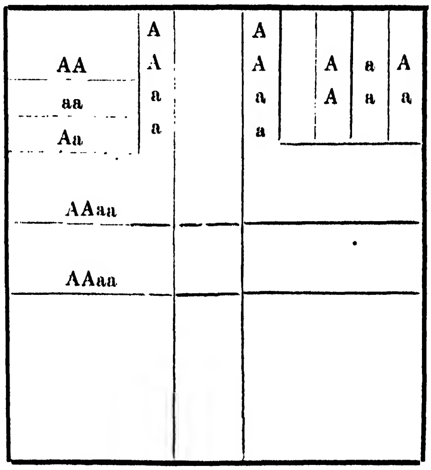
justified only on the score of convenience afforded in working the model.

The idea of indivisibility of the determiners and their segregation in the sexual cells involves the reduction in the sexual cells of a double dose when it is present in an organism to a single dose, and the formation of two sorts of sexual cells in equal numbers one carrying a single dose and the other a nil dose when the organism itself has got only one dose. This implies the existence of sexual cells of only two types with reference to a given determiner, one type carrying a single dose of it and the other none of it. Thus there are three types of organisms represented by the conventional symbols **A A, A a,** and **a a,** and called homozygous or pure dominant, heterozygous or hybrid dominant, and recessive which is always pure; but there are only two types of sexual cells. *viz.*, **A** and **a.** This fact is generally embodied in the doctrine of purity of gametes. Segregation is commonly spoken of in Mendelian literature, following Mendel's own conception of "pairs of differentiating characters and their mutual separation in the sexual cells" as "the dissociation of the allelomorphic or alternative characters in the constitution of the gametes," or symbolically the separation of A a from each other. The separation of A A and of **a a** (Mendel conceived of **a a** not as an absence but as a presence) also from each other was not noticed by Mendel, and has also apparently escaped the attention of most writers on Mendelism. The composition of different zygotes and of their gametes with reference to one character may be represented thus—

Zygotes	A A	A a	a a
Gametes	all A	A and a in equal numbers	all a

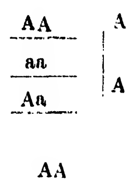
In my model which consists of a square frame work standing erect and carrying strings of beads the composition of the different types of organisms and of the gametes is shown by beads on different strings. The strings carrying the beads for gametes of one parent cross those of the other parent, and the composition of the resulting zygotes is shown by moving the beads to the points of intersection.

The following diagram which deals with the consideration of one character only will render clearer what I have just stated.



Note. The beads in the top left-hand square represent the zygotes and those in the top right-hand square the gametes produced by these zygotes.

It may be further simplified as given below which requires only fourteen beads in all.



When two characters are considered conjointly there would be nine (3^n, n being the number of characters considered as stated by Mendel), different forms of zygotes represented by the symbols AA BB, AA bb, aa BB, aa bb, AA Bb, Aa BB, Aa bb, aa Bb and Aa Bb, and there would be four (2^2) different forms of gametes, *viz.*, AB, Ab, aB and ab.

In the model the strings of beads representing the gametes should be in pairs, one string for the determiners of each character. Since there are four different forms of gametes there should be four pairs of strings. The four vertical pairs would cross the four horizontal ones and thus there would be sixteen groups of crossing, each group consisting of four crossings. The formation of zygotes is represented in the central square by moving the requisite beads to the points of intersection. If it is desired to reproduce the conventional arrangement when demonstrating the effect of selfing of AaBb or of crossing of a zygote AaBb with another which is also AaBb, the four types of gametes on the four pairs of strings should be arranged in the order **AB, Ab, aB** and **ab** from left to right on the vertical strings, or from above downwards on the horizontal strings.

In the demonstration of the working of three characters taken conjointly, there would be twenty-seven (3^3) possible forms of zygotes to be considered. These may be arranged as follows though any other order would serve the purpose.

Group I	AA BB CC		
,, ,,	AA BB cc	AA bb CC	aa BB CC
,, ,,	AA bb cc	aa BB cc	aa bb CC
,, ,,	aa bb cc		
Group II	AA BB Cc	AA Bb CC	Aa BB CC
,, ,,	AA bb Cc	aa Bb CC	Aa BB cc
,, ,,	aa BB Cc	AA Bb cc	Aa bb CC
,, ,,	aa bb Cc	aa Bb cc	Aa bb cc
Group III	AA Bb Cc	Aa BB Cc	Aa Bb CC
,, ,,	aa Bb Cc	Aa bb Cc	Aa Bb cc
Group IV	Aa Bb Cc		

In the model, **ABC** are represented by three kinds of beads which differ in colour, shape, and size, and **abc** by corresponding beads which are colourless. The twenty-seven genotypes fall into four groups according to their behaviour in breeding when selfed and I have assigned to each of them a separate corner in the model. In the first group there are eight genotypes which are quite constant. These are placed in the left-hand top corner. The second group which contains twelve forms includes genotypes in which one of the three characters will split. The third group of six forms contains two of the three characters splitting. The last group which contains

only one form has none of the characters constant. The above grouping also brings out the frequency of the occurrence of different forms when Aa Bb Cc is selfed. The resulting combinations form a series of 64 in which the eight genotypes of the first group appear once only, the twelve genotypes of the second group appear twice only, the six types placed in the third group appear four times, and lastly, the single type in the fourth group appears eight times The following table makes this point clear :—

8×1	8
12×2	24
6×4	24
1×8	8
	—
	64

If it is desired to bring out the phenotypic composition as well, it may be done by adding eight squares to the model in any fashion whatever. I would suggest their provision in an oblong frame with eight compartments added to the model at the top of it. The twenty-seven genotypes may be arranged in eight phenotypic groups as follows :—

1. Phenotype ABC having eight genotypes.

AA BB CC
AA BB Cc   AA Bb CC   Aa BB CC
AA Bb Cc   Aa BB Cc   Aa Bb CC
Aa Bb Cc

2. Phenotype ABc having four genotypes.

AA BB cc   AA Bc cc   Aa BB cc   Aa Bb cc

3. Phenotype AbC having four genotypes.

AA bb CC   AA bb Cc   Aa bb CC   Aa bb Cc

4. Phenotype aBC having four genotypes.

aa BB CC   aa BB Cc   aa Bb CC   aa Bb Cc

5. Phenotype Abc having two genotypes.

AA bb cc   Aa bb cc

6. Phenotype aBc having two genotypes.

aa BB cc   aa Bb cc

7. Phenotype abC having two genotypes.

aa bb CC   aa bb C

8. Phenotype abc having one genotype.

aa bb cc

So far I have dealt with simple factors. An effective demonstration of complementary factors is obtained by using tiny bits of sponge dipped in appropriate chemical solutions instead of beads. Thus bits of sponge dipped in phenolphthalein and caustic potash solutions may be used to demonstrate the production of coloured flowers by crossing two white forms. Other phenomena of Mendelian inheritance such as cumulative factors, inhibitory factors and gametic coupling can as well be demonstrated on the same principles. I propose to deal with these in detail in a subsequent paper, as also with the modification required to be made when the recessive characters are supposed to be due to the presence of definite recessive determiners.

THE CORRELATION OF RAINFALL AND THE SUCCEEDING CROPS WITH SPECIAL REFERENCE TO THE PUNJAB.*

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Introductory. In the first application of the method of correlation to the problem of the numerical measurement of the dependence of crops on rainfall in India, only the general effect of the whole summer and winter rainfalls on the autumn and spring harvests respectively was considered. In the present paper the effect of the distribution of rainfall in time is more specifically dealt with, and, too, the more important crops have been treated separately; both being very necessary steps towards the complete determination of the character of the harvest from the antecedent rainfall.

Increasing attention has been devoted of late years to attack on the same problem by similar methods in other countries, more particularly in America, and there has been obtained a sufficient number of high coefficients of correlation to encourage further investigation on the same lines.†

* This paper is also published as a Memoir of the Meteorological Department of the Government of India.

† The more notable values obtained hitherto are :—

(1) A double correlation coefficient of +·80 of Spring rain and accumulated temperature with outturn of hay from clover and rotation grass for Eastern England. Hooker.—*Journal Roy. Stat. Soc.*, 15-1-1907.

(2) A total correlation coefficient of +·73 between the rainfall of October to March and the unirrigated matured area of the Spring harvest for the Sialkot district of the Punjab, and a double correlation coefficient of +·80 for similar data for the Delhi district. Jacob.—*Memoirs of the Asiatic Society of Bengal*, 3-2-1909. (*Continued on page* 87).

The tract selected : Jullundur Tahsil. The tract I have dealt with is the Jullundur Tahsil of the Jullundur District situate in the Doaba between the rivers Beas and Sutlej. The area of the Tahsil is 428 square miles of which practically 390 are cultivated, and it is divided into three Assessment Circles, which are roughly homogeneous in respect of their soil, climate, and their courses of husbandry. There are no canals and as a rule very little flooding, so that the problem of rainfall effect is not too complicated. But there is a very large number of wells, and during the last 30 years more wells have been steadily added to both the Dona Lehnda and Dona Charhda Circles, and this means that there is a concomitant diminution of unirrigated crops, for which allowance has to be made in considering the variation in the areas sown each harvest on unirrigated land. Thus in the Dona Charhda Circle every fresh well sunk has meant that on the average 2·2 acres cease to be classed as unirrigated for the purposes of the Spring harvest. Of this diminution a loss of :--

0·66	acres per new well falls on unirrigated	wheat sown,
1·20	,, ,, ,, ,,	wheat and gram,
0·18	,, ,, ,, ,,	gram alone,

and the balance of ·16 acres on other crops.

The countervailing gain in Spring irrigated crops is however no less than an additional 7·4 acres for each additional well, of which 3·36 acres per well, or rather less than one-half, has been an increase in wheat sowings. Before the correlation of the areas sown with the rainfall are worked out, the crude figures must in all cases be corrected by the appropriate factors, these being slightly different for each of the three Assessment Circles.

Distinction between the two problems—sown area and yield. Two entirely distinct problems present themselves if we propose

(3) A correlation of −·69 between accumulated temperature and potato yield Warren Smith.—*U. S. Monthly Weather Review*, May 1911.

(4) A correlation of −·70 between the effective rainfall of July 21 to August 20, and the yield in corn in Ohio. Warren Smith —*U. S. Monthly Weather Review*, February 1914.

(5) A correlation of ·88 between rainfall and temperature in April to September and the yield of cotton in Texas. J. B. Kincer —*U. S. Monthly Weather Review*, February 1915.

to forecast the amount of crop of any harvest, and these are :—

(1) The determination of the area sown with each class of crop.

(2) The determination of the percentage of the crop which is likely to come to maturity, or, in other words, the yield or outturn per unit of area.

The first problem, which is, for not too great a cycle of years, in the main a problem of rainfall and temperature, is also an economic and psychological problem—prices of seeds, scarcity of labour, population, mortality, the standard of living, the number of plough cattle, mechanical aids to cultivation, and political events—all having contributory effects. Yet, unless the fluctuations in these subsidiary causes are very violent, they will not mask the first order effect of rainfall, and the proper method is to deal with the large effects first, and then proceed to disentangle the residual effects. This is the invariable scientific practice in those cases, for example in astronomy, in which we cannot control the phenomena.

The second problem, the determination of the yield of each crop per acre, is much less an enonomic problem than the preceding one, especially in dealing with unirrigated crops which are not much manured or weeded, and is really a joint problem of meteorology, subsoil physics, and plant biology. It is a statistical problem only on account of its complexity ; and the more physical and biological laws can be applied to it, the smaller will be the residual unexplained effects to which it will be necessary to apply statistical methods.

Prediction of areas sown.

Correlation of rainfall and sown areas. I take first the problem of predicting the extent of sowings, and give the total correlations of some only of the crops which have been considered for each Assessment Circle, namely, for *chahi* (well-irrigated) wheat, wheat and gram unirrigated, and all unirrigated crops together, for the Spring harvest based on the figures of the thirty years 1886-1915.

The correlations are :—

		July	August	September	October
Chahi wheat ...	Dona Lehnda	-0·38	-0·25	0·52	......
	,, Charhda	......	-0·28	-0·53	-0·34
	Sirwal ...	... ..	-0·01	-0·50	-0·39
Barani wheat and gram.	Dona Lehnda ...	0·18	0·21	0·54	...
	,, Charhda ...	.. ...	0·13	0·54	0·19
	Sirwal	......	0·16	0·27	.. .
All Barani Spring crops.	Dona Lehnda ..	0·21	0·04	0·37	..
	,, Charhda ...	... ..	0·17	0·48	0·33
	Sirwal	......	-0·06	0·48	... .

The July and August coefficients are in the neighbourhood of 0·20 with a probable error of ± 0·12, or, on the simple theory of probability, the odds in favour of these correlations being significant are 7 to 1. The simple theory, however, by no means gives a favourable enough estimate of the odds when we find coefficients of about the same magnitude repeated again and again. In fact the repetition of the correlations for three different areas, supposing the sown areas in each case are unassociated except on the score of a more or less common rainfall, makes the odds nearly 350 to 1. So that I think that we may justly conclude that the correlations with July and August rainfalls are significant. In any case it is highly probable that they are significant, as the rainfall in these months is a true contributory cause of the autumn sowings of September, October, and November.

The correlations of sown area with September rain are in the neighbourhood of 0·50 with a probable error of ± 0·09, so that the simple odds in favour of the significance of this correlation are over 80,000 to 1, so that this coefficient is undoubtedly significant. The frequency with which nearly the same value of the correlation is found for this and other districts of the Punjab makes the odds much greater even than this.

The correlations for October are on an average about 0·23 with a probable error of ± 0·11, or the odds in favour of their significance are 18 to 1.

A further point of importance with regard to the correlation with September rain is that the odds are 9 to 1 against its being as

low as 0·325, and we are not likely to be wrong if we say that it lies between 0·4 and 0·6. For lower correlations we cannot predicate such narrow limits between which the correlation coefficient is likely to lie.

The coefficients are the simple or so-called total correlation coefficients, but they do not represent the actual rainfall effect and it is necessary to eliminate the error due to the fact that the rainfalls in the different months are themselves correlated, and so it is possible that the area sown is spuriously correlated with the August rainfall simply because it happens to depend on the September rain, which in its turn is correlated with the August rainfall.

If the rainfalls in August, September, and October (July rainfall has been left out of account because of the doubt of the magnitude of its effect on autumn sowings) are positively correlated *inter se*, then this fact will have given a fictitiously high value to all the correlations; but, if on the other hand the rainfalls are negatively correlated among themselves, the true magnitude of the crop correlations will have been masked, and we may have considerably to increase the total correlations previously found. This latter is actually the case. The correlations of the rainfalls are:

August with September	−0·37
,, ,, October	−0·10
September with October	−0·13

So that it is clear that the true or so-called net coefficients of correlation are markedly larger than the values previously stated. The valuation of the net coefficients of correlation is a somewhat laborious process, and for the Jullundur data I have limited myself to the two cases of greatest interest, namely, for well-irrigated wheat and for all unirrigated crops together.

Prediction for Chahi wheat. I take firstly the case of well-irrigated wheat in the Dona Charhda Circle for which the average area sown in the last 30 years is 19,100 acres, with a standard deviation of 4,080 acres or 21·3 per cent. The net correlations of the area sown each autumn are as follows:—

With August rainfall	−0·79
,, September ,,	−0·86
,, October ,,	−0·74

These average at about 0·80 with a probable error of ± 0·08, and the odds are thus over 20 to 1 against the coefficients being as low as – 0·60 in absolute value, and nearly 200 to 1 against their being as low as – 0·5, so that we may say that these coefficients are almost certainly greater than 0·6.

From these correlations we determine the equation expressing the area sown with wheat on well-irrigated lands in terms of the rainfall departures from the mean, namely: —

$$S' = 18{,}890 - 570\ D_8 - 750\ D_9 - 4{,}300\ D_{10},$$

where D_n is the departure of the rainfall of the nth month from the average rainfall of the month.

The equation shows what an enormous effect rain in October has in causing the cultivator to abandon wheat sowings on well-irrigated lands: in fact an inch of rain in October would throw out nearly 6 acres of well-irrigated wheat, as against one acre thrown out by an additional inch of rain in August.

The equation must not, however, be interpreted to mean that every successive increment of rain will throw out further equal amounts of well-irrigated wheat, as the relation between the rainfall and the area sown is certainly not linear when we come to large departures from the average. All that we can assert from the equation is that rainfall of the quantity and distribution that fell during the years 1885—1914 in August, September, and October did, on the whole, have the effects noted. Of course in considering what effects rainfall in the different months has on well-wheat sowings we must remember that it is much more usual to have a departure of one inch of rain in August or September than in October, and properly to compare the effects of rainfall as it did occur in the last thirty years we must multiply the regression coefficients of each month by their respective average rainfalls. We find thus that actually the relative effects of August, September, and October rainfall were as 2 : 3 : 1, the reason for the low October effect being due to the fact that it is the exception to get rain in October at all. If it does fall it has, as we have seen, a much greater effect than rainfall in the previous months in diminishing sowings of well-irrigated wheat.

When the appropriate correction for the number of wells has been introduced the final formula of prediction for the sown area of *chahi* wheat is :—

$$S = 3{\cdot}6\,(w\text{-}5540) + 26{,}910 - 570R_8 - 750R_9 - 4300R_{10},$$

where R_n is the total rainfall in the nth month, and w is the number of wells in the Assessment Circle.

The multiple coefficient of correlation of sown area and the 'weighted' area is 0·89, so that the prediction formula, so far as a linear expression can give the relationship, is a good one.

From this formula the sown area has been calculated for each year from 1885—1914 and the results are shown graphically in Diagram I, which shows also the actual sown areas.

The correspondence between the observed and calculated results is seen to be distinctly close. The probable error of the prediction is $0{\cdot}67 \times \sigma_{1{\cdot}234} = 1050$, or 5·6 per cent. of the mean.

Constancy of other crops. A very important fact may here be referred to, namely, that if we group together all well-irrigated Spring crops excluding wheat, and wheat and gram and form a class of 'other crops' which consists mainly of the fodder crop, senji, melon, tobacco, and other vegetables,* the sown area of this class after the correlation for numbers of wells has been applied is remarkably constant from year to year having a coefficient of variation of only 5·9 per cent. as against one of 21·9 per cent. for well-irrigated wheat, so that the prediction from an appropriate rainfall formula would have a probable error of about 2 per cent. only.

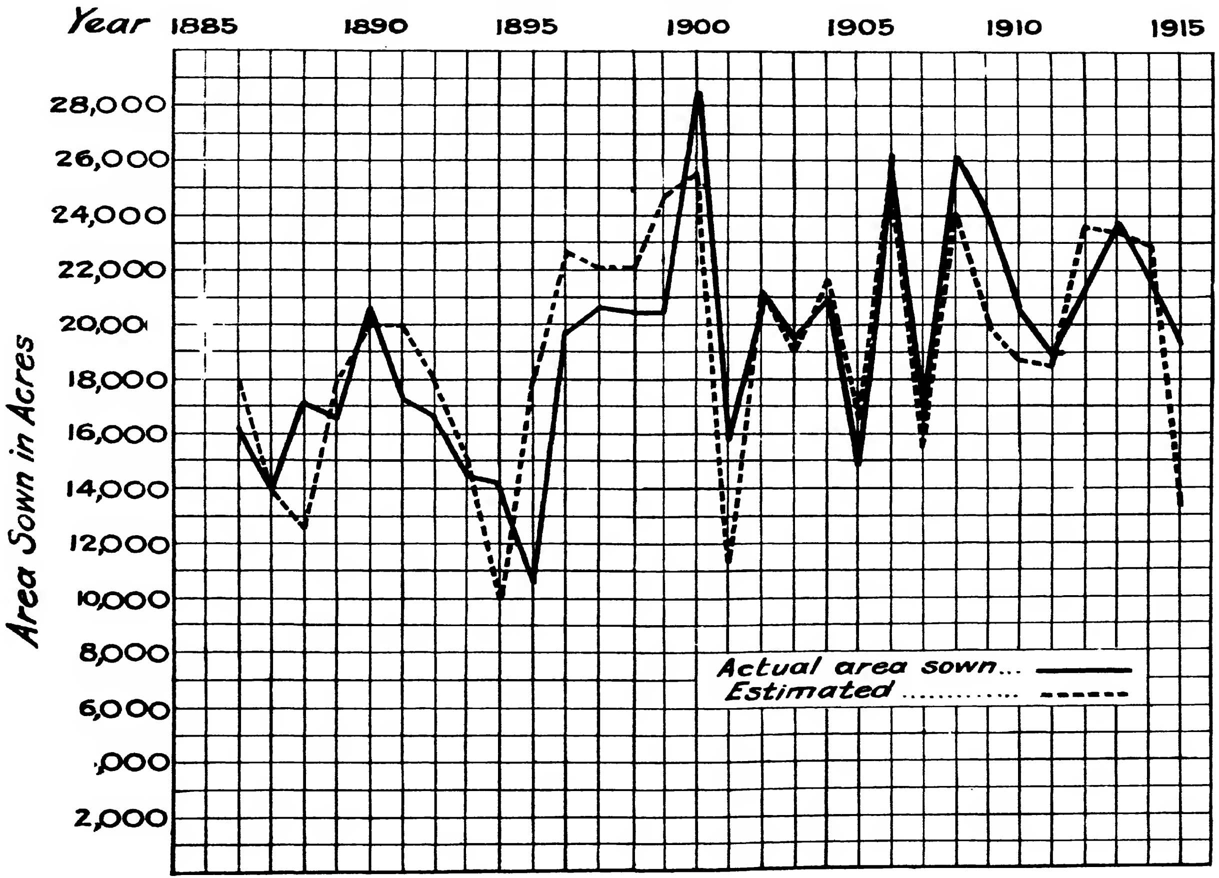
Prediction for all barani rabi crops. The next case treated is that of all unirrigated (*barani*) Spring crops taken together.

The prediction of the sown areas of individual unirrigated crops is very desirable, but except for the principal crop, wheat and gram combined, the problem will require a finer analysis than by the total rainfall of the month. Thus the 30th of September is a critical time. If sowing conditions are favourable before that date, a great deal of gram is likely to be sown, but if suitable rain falls after that, gram is almost always combined with wheat. Wheat

* This group of crops consists of those grown for local consumption of man and beast and are very little affected by external supply and demand.

DIAGRAM I.

Dona Charhda CHAHI WHEAT.



in particular requires very favourable conditions if it is to be sown on *barani* land, and an examination of monthly rainfall does not suffice to show the fluctuations in the area sown, which in all three parts of the Tahsil shows a steady fall from 1885 onwards with a minimum between 1900 and 1905 and a very marked rise in the last 10 years.

The regularity of the change suggests a secular cause such as Dr. Shaw's 11 years' periodicity from wheat in England. At any rate the general trend of the data can be fitted with a smooth curve.

Parabolas fitted by the method of least squares are fair representations, but would certainly break down for extrapolation purposes.

For the sown areas of all unirrigated Spring crops together the net correlation coefficients are :—

With August rainfall	= + 0·57
,, September ,,	= + 0·72
,, October ,,	= + 0·59

The combined coefficient of correlation is 0·77 so that fair prediction is to be anticipated. Taking the coefficients of the linear regression formula, and multiplying them by the appropriate constant, the expression

$$\cdot 147\ R_8 + \cdot 53 R_9 + 2\cdot 66 R_1$$

is obtained which may be called the weighted rainfall. If the weighted rainfall is taken as the abscissa and the area sown corrected for the number of wells as ordinate we get a distribution of the kind as shown in Diagram II which clearly indicates that to a second approximation the data can be fitted with a curve of the form

$$y^n = ax - bx^2,$$

and after a number of trials the curve

$$y^8 = 34x - 1\cdot 7x^2$$

was found to be a fair but not a good approximation to the changes. The curve rises abruptly at the origin, but it would have been better to make it rise abruptly at 2″ of the rainfall, which is about the minimum required for any sowings at all. It reaches a maximum at 30″ of weighted rainfall, that is to say,

beyond that, more rainfall would interfere with sowings. About the same maximum was found for data in the old Delhi District. The problem however must be attacked by a systematic curve-fitting method, which should substantially reduce the probable error of prediction which is $0 \cdot 675 \times 5700 = 3840$ acres or 9 per cent. of the mean, an appreciably larger error than in the case of irrigated wheat, although the coefficient of variation is about the same, 22 per cent., in both cases. Even as it is, the prediction afforded is a distinct advance on existing practice.

Prediction of Outturn.

Nature of problem. The next step after finding out how much crop is sown is to find out how much of it is going to come to maturity, and that is as for human beings, both a bathmic and an environmental problem, condition of seed, state of the seed bed, and the treatment and climate from the time of sowing to the time of harvesting, being the factors to be taken into account.

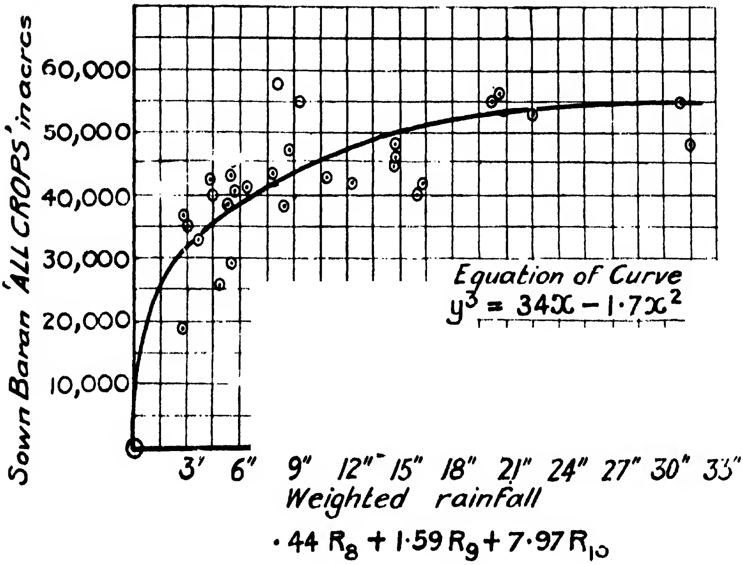
In the present paper unirrigated wheat only is dealt with by the statistical method, and the condition of seed has not for the moment been taken into account; but the state of the seed bed which depends, in the main, on the September and October rainfall, is taken into account as well as the rainfalls in each of the subsequent winter months, November to March.* The antecedent rotational crop which is a very important factor in considering individual fields is a quite subsidiary point in the aggregate over such a large area as an assessment circle, in which there will be many fields in different stages of the crop rotation. As a matter of fact, unirrigated wheat is generally sown after a 10 months fallow and is followed by *charri, moth,* or *guara,* in the subsequent June or July (*dofasli dosala*) or on the better class of unirrigated (*barani*) soils, wheat is sown year after year (*ek fasli ek sala*) with no intermediate crop. The outturn is determined in the Punjab Revenue Papers from the

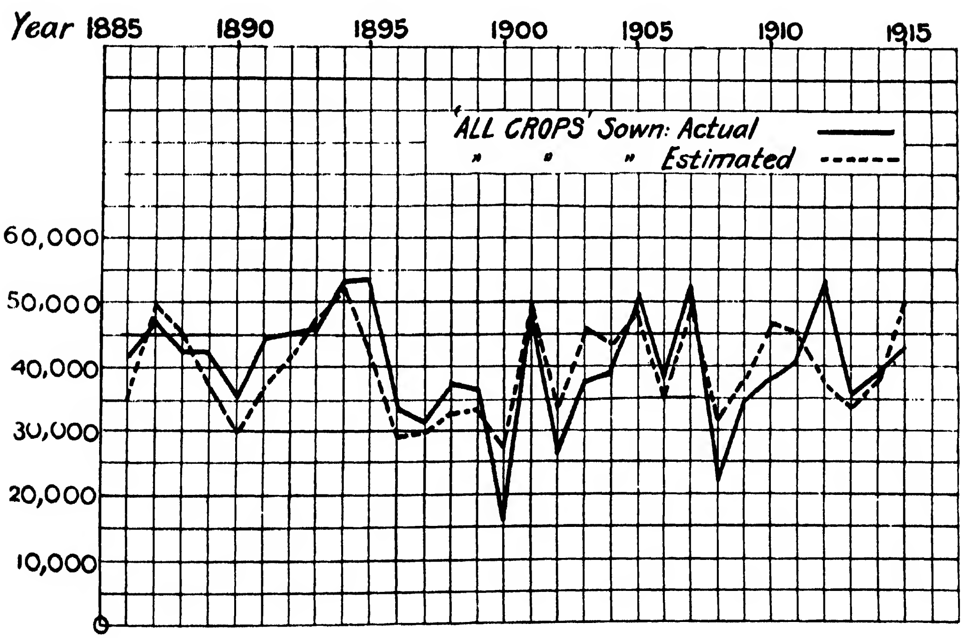
---

* An analysis which aimed at completeness would naturally include not merely rainfall but all climatological factors, such as temperature, sunshine, precipitation in the form of dew, evaporation, wind, and so forth, defect or excess of which may on occasion reduce an otherwise promising crop to a very poor condition. Given the opportunity the analysis can be so completed.

DIAGRAM II.

Dona Chart-da ALL BARANI RABI CROPS SHOWN.





area of the crop which fails to come to maturity, the so-called *kharaba* which is merely the Patwari's estimate of the deficiency of the particular field below what he considers a normal value.

His estimate is checked by various Revenue officials of higher grade, but it still remains subject to a very large personal equation. In particular during the last 15 years there has been much greater liberality in allowing *kharaba*, and in dealing with the statistics the last 30 years have been divided into two periods. The results based on the second period are probably the more reliable. Crop experiments are, as at present conducted, of a very perfunctory kind, and two or three of them for each principal crop per Tahsil, would be required to get results truly indicative of the character of the harvest. It is much to be regretted that a proposal to do away with crop experiments altogether has been mooted. It is quite as important that accurate outturns should be determined for crops grown by cultivators under normal conditions, as for crops grown for special test purposes by the Agricultural Department.

Prediction by multiple correlation. Taking the figures for *kharaba* as we have them the correlations of rainfall and failed area for the various crops are :—

Correlations of percentage kharaba with rainfall in the winter months.

	Assessment Circle	September	December	January	February	March
Chahi wheat ...	Dona Lehnda ...	......	-0·36	-0·19	-0·27	-0·27
	,, Charhda .	-0·41	-0·46	+0·01	-0·21	-0·36
	Sirwal ...	.. ...	...	......	......	...
Chahi all crops ...	Dona Lehnda .	......	...	......	.. .	.....
	,, Charhda ..	-0·46	-0·39	-0·18	-0·25	-0·43
	Sirwal ...	-0·08	-0·05	+0·17	-0·02	-0·15
Barani wheat ...	Dona Lehnda ...	...	-0·31	-0·16	-0·19	-0·07
	,, Charhda ...	-0·37	-0·40	-0·16	-0·26	-0·26
	Sirwal ..	-0·12	-0·07	+0·23	-0·02	-0·14
Barani wheat gram...	Dona Lehnda	...	-0·13	-0·14	-0·19	-0·23
	,, Charhda ...	-0·37	-0·31	-0·19	-0·31	-0·35
	Sirwal ...	-0·54	-0·33	-0·11	-0·37	-0·41
Barani gram ...	Dona Lehnda ..	......	......	...	......	.. ...
	,, Charhda ..	-0·43	-0·51	-0·19	-0·31	-0·35
	Sirwal ..	...	...	..	... .	...
Barani all crops .	Dona Lehnda ..	... ..	-0·23	-0·20	-0·14	-0·22
	,, Charhda ...	-0·40	-0·40	-0·17	-0·32	-0·24
	Sirwal ...	-0·42	-0·32	-0·07	-0·26	-0·28

The Dona Lehnda results are for the 30 years 1886-1915. For Dona Charhda and Sirwal for 1901-1915.

A noticeable feature of the figures is the high negative correlation with September rainfall, additional evidence, were any necessary, of the value of a moist seed bed for germination.

I have not had sufficient time at my disposal to discuss in great detail the results for all three Assessment Circles, and for this reason it was necessary to limit the further analysis to a single crop and a single assessment circle. Accordingly the most important crop, wheat, has been selected, and that Assessment Circle in which the rain gauge is situated.

I emphasize only the Dona Charhda figures for unirrigated wheat which are :—

	September	December	January	February	March
Whole period 1886—1915	−0·30	−0·30	−0·27	−0·19	−0·24
First „ 1886—1900 ...	−0·25	−0·25	−0·46	−0·02	−0·19
Second „ 1901—1915 ...	−0·37	−0·40	−0·16	−0·26	−0·26

These figures are consistent *inter se* and with all the other Circles and crops and their significance is accordingly greater than it would be if measured merely by their probable errors.

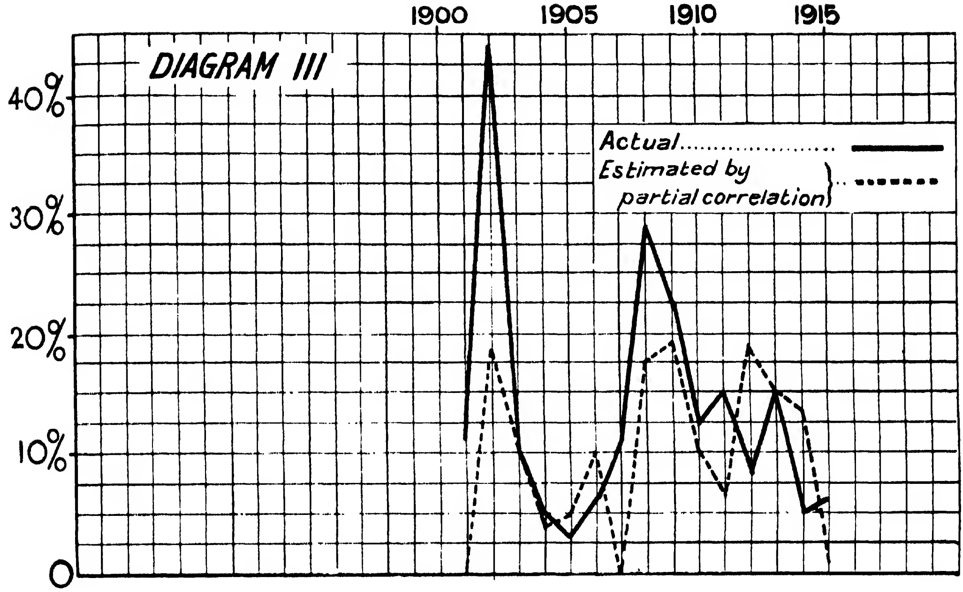
On the figures of the last 15 years I have calculated a provisional regression formula based on the erroneous assumption that the rainfalls in these five months are not correlated to each other.

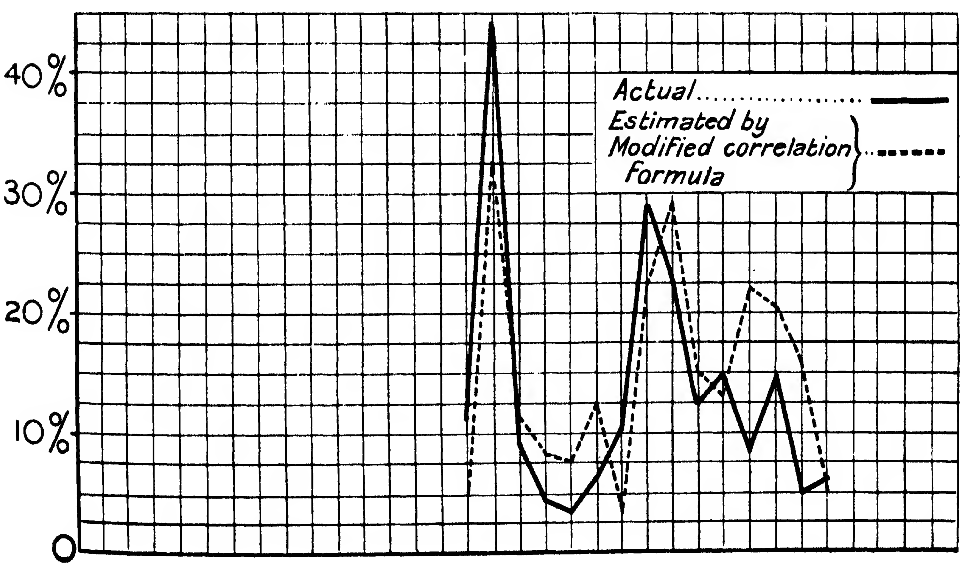
Actually there is no significant correlation between the rainfalls of December and February, January and February, February and March.

In fact the February rainfall seems a very detached effort, but there is a substantial correlation in the rainfalls in the other months. The concordance between calculation and fact is shown in Diagram III. The agreement would have been much better had these mutual rainfall correlations been taken into account, but a multiple regression formula based on six variables takes a long to evaluate time and on account of pressure of much other work I had to abandon it.

Kincer's method. Moreover, Dr. Simpson having drawn my attention to an alternative, and in some ways a preferable method

Dona Charhda. WHEAT KHARABA.





of dealing with the problem, developed by J. B. Kincer in the *U. S. Monthly Weather Review* of February 1915 for dealing with the yield of cotton in *Texas*, it seemed of importance to apply the method to yields of Indian crops. Kincer's results being so good that a correlation of 0·88 is obtained.

Kincer assumes that the most favourable conditions for cotton are the normal ones, and that any departures from these, whether above or below, whether of rainfall or temperature, are harmful. There would seem to be *a priori* justification for this in dealing with a crop with centuries of development in a single place behind it, but expert opinion would be advisable before adopting it for Indian crops particularly for imported plants.

Kincer adopts certain numerical values for the harm done by rain, or heat, or cold, according as a plus deviation follows a plus deviation, a minus a minus, and so on, thus :—

	RAINFALL					
	April	May	June	July	August	September
+ following + or 0 ...	4	8	8	4	4	4
+ ,, − ...	4	4	2	2	2	3
− ,, − ...	4	5	6	8	10	8
− ,, 0 or + ..	2	2	3	6	8	4

Naturally a sequence of months with the same departure from normal is weighted as the most harmful.

He has a similar table for temperature :—

	April	May	June	July	August	September
+ Temperature with 0 or + rain.	1	1	1	1	1	1
+ T with − R ..	1	1	2	2	2	1
− T with − R ...	1	3	2	2	2	2
− T with + R ...	1	4	4	2	2	2

He has in addition certain slight modifications of the value to be introduced when during several months the same conditions obtain.

The values are stated "to have been fixed empirically from a general knowledge of the effect or plant development of certain combinations of weather," but what constitutes a plus, zero or a minus departure is not stated except that 0·3 of an inch of rain less than the normal for April or May is considered as minus.

Application of Kincer's method to unirrigated wheat. In applying Kincer's method to the yield of unirrigated wheat in Jullundur District, it seemed much better to assume that all departures of rain above the normal are beneficial and *vice versâ,* not because this is true for all crops in all places, but because with the soil and rainfall which actually obtain in that district, it is very rare for excess of rain to be markedly harmful.

In order to make the scheme as little arbitrary as possible the rainfall distribution curves have been plotted for each month, and divided into three equal areas which are marked –, O, + respectively.

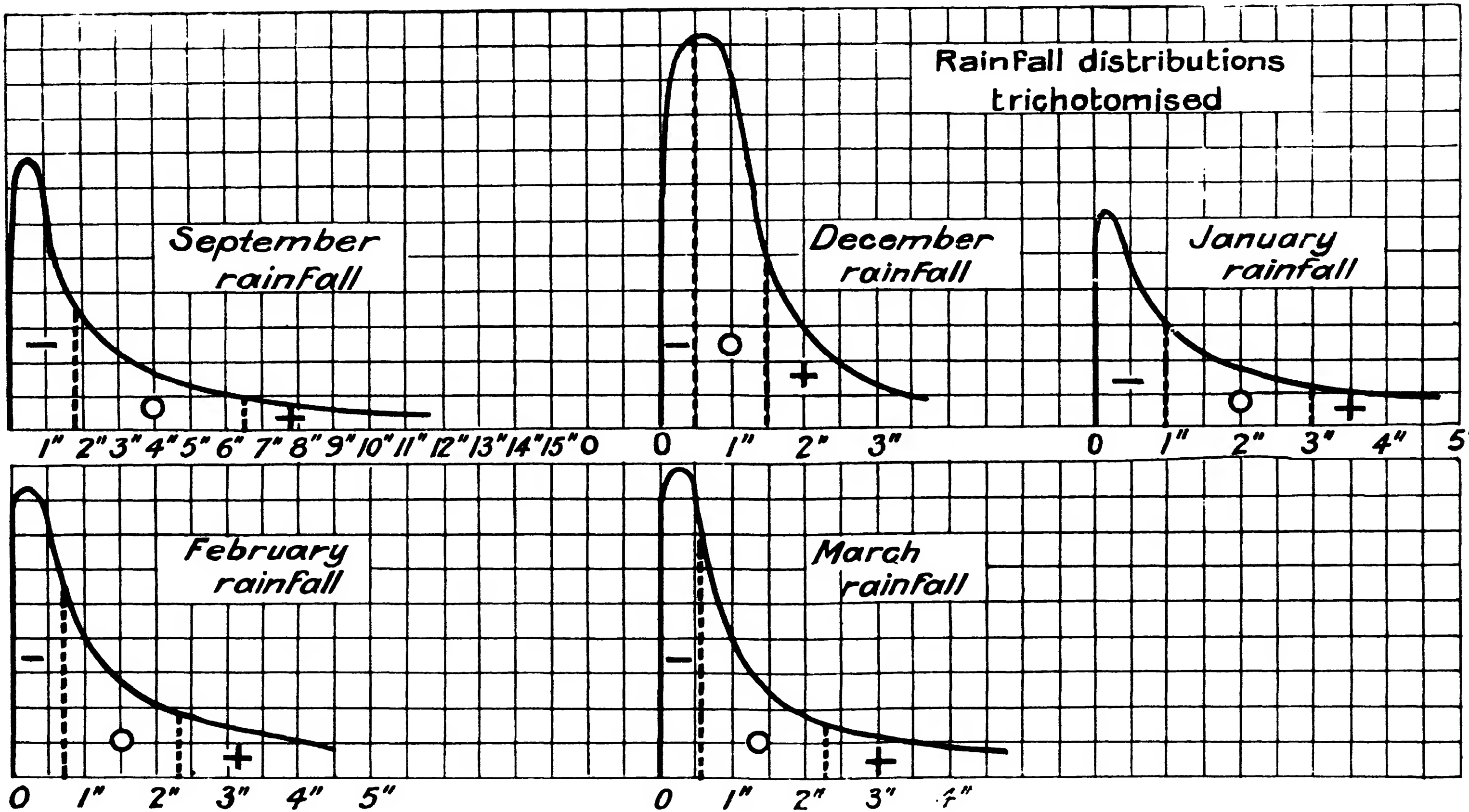
The trichotomy is exhibited in the accompanying Diagram IV. Thus :—

		–	0	+
		Less than	Between	Above
September	...	1″·8		6″·5
October	...	0″·1		0″·5
November	...	0″·1		0″·5
December	...	0″·5		1″·5
January	...	1″		3″
February	...	0″·7		2 ·3
March	...	0″·6		2″·2

Rainfalls in each month are then weighted according to the following scheme (September rainfall weight = 5).

Rain departure for September	Benefit of October and November rain
+	0
0	0
–	20
	Benefit of December rain.
+	1
0	2
–	3

DIAGRAM IV.



Rainfall distributions trichotomised
September rainfall
December rainfall
January rainfall
February rainfall
March rainfall
1" 2" 3" 4" 5" 6" 7" 8" 9" 10" 11" 12" 13" 14" 15" 0
0 1" 2" 3"
0 1" 2" 3" 4" 5"
0 1" 2" 3" 4" 5"
0 1" 2" 3"

	Rain departure December	Benefit of January rain
+	+	1
	0	2
	–	3
0	+	2
	0	3
	–	4
+	+	3
	0	4
	–	5

		Rain departure January	Benefit of February rain
+	+	+	1
		0	2
		–	3
	0	+	2
		0	3
		–	4
	–	+	3
		0	4
		–	5
0	+	+	2
		0	3
		–	4
	0	+	3
		0	4
		–	5
	–	+	4
		0	5
		–	6
–	+	+	3
		0	4
		–	5
	0	+	4
		–	5
		0	6
	–	+	5
		0	6
		–	7

The only modification which was necessary to this was the addition of the factor 20 to every 0 above 2 in number occurring in the months September, December, January, February and March, thus indicating that long continued normal conditions are, as in the case of cotton in Texas, very favourable.

The weighted rainfall in each month was added together, and a coefficient of benefit B obtained, and this was correlated with the area of unirrigated wheat for 1900-1915. The correlation is $-0{\cdot}91$,

even higher than Kincer's figure of 0·88. The formula giving the percentage of failure in terms of the coefficient B is

$$K = 24{\cdot}2 - {\cdot}35B.$$

The *kharaba* calculated from this formula is plotted with the actual figures of *kharaba* in Diagram V. I think the agreement of the two values shows that the formula is a very good one and affords *a posteriori* justification of the hypothesis.

The introduction of suitable corrections for other climatic factors, such as temperature, sunshine, evaporation, precipitation in the form of dew, wind and the like would improve the prediction still further.

Betterment of Prediction.

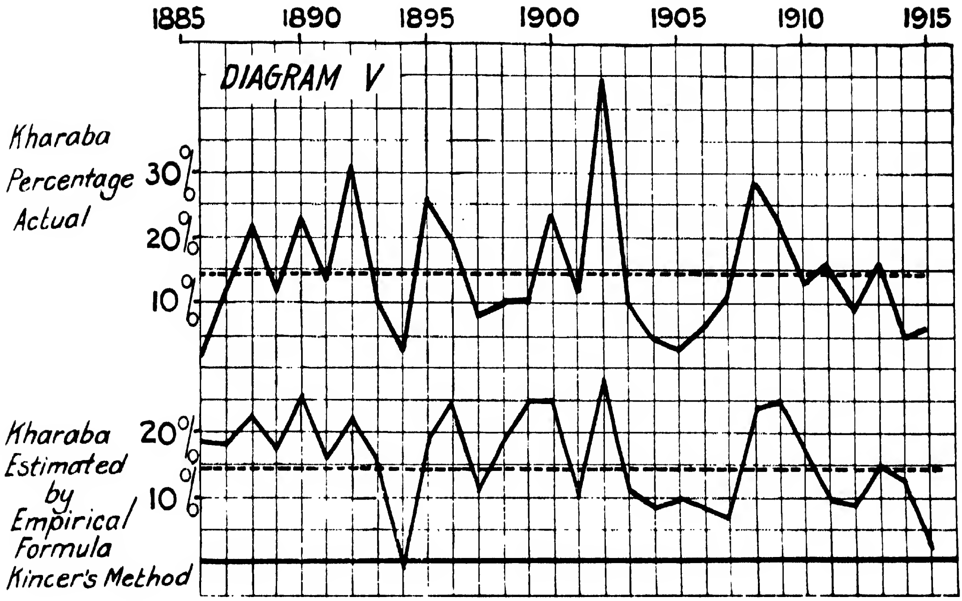
Subsoil water. The method of correlation is not a method apart, dissociated from other methods of analysing observed facts; on the contrary, the more physical and chemical laws we can make use of before we start correlating the better.

For example in forming the prediction equations for sown areas, we have correlated rainfalls in August, September, and October with the areas sown in September, October, and November, but what we really want to know is, what the cultivator has a shrewd knowledge of, when he puts in his crop, and that is the state of the subsoil moisture, and also the temperature of the seed bed.

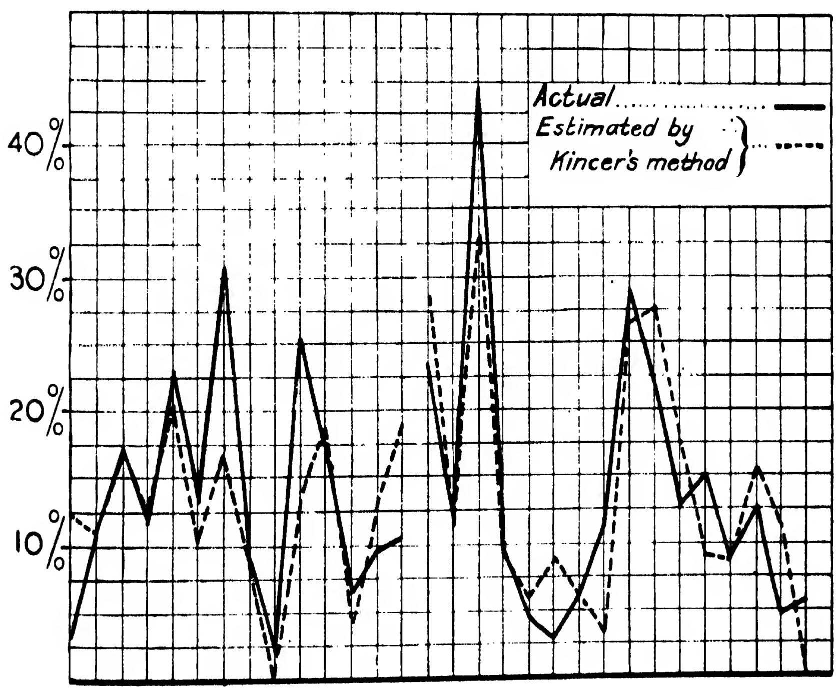
The problem is, given the rainfall and temperature throughout the monsoon period, what is the distribution of the subsoil moisture when *rabi* sowings commence. I have been unable to find even in Leather's valuable researches the complete answer to this question. He has indeed shown,* that if evaporation is an exponential function of the time, the quantity of water in the first seven feet of Pusa soil can be found from the known temperature and humidity from September till June, but as the question of run-off, which in the monsoon is all important, is not quantitatively worked out, it does not seem possible to apply the results without further

* Leather, J. W. Water requirements of crops in India. *Mem. Dept. of Agri. in India Chem. Ser.* vol. I, no. 8.

Dona Charhda WHEAT KHARABA.



WHEAT KHARABA.



experiment to the Punjab. It seems very desirable to repeat the Pusa experiments in all typical Punjab districts, and it should be possible as a result of them to state once for all a formula giving the soil moisture at the close of the monsoon, for each foot of subsoil in terms of the antecedent rainfall and the size and nature of the particles composing the soil.

The complete hydrodynamical solution of the movement of the subsoil water has not so far been obtained, but on the assumption that the velocity is proportional to the first differential of the relative saturation of the soil and that the ratio of surface of all particles per unit of volume to the saturation quantity of moisture is constant, an integrable equation results, for a linear change of particle surface with depth.

This is a great limitation. Further experiment in this country is urgently required, and from a sufficiently extended series of data assumptions could be made leading to a more or less accurate general solution.

Lastly as to the determination of yield, what we want to know is not merely what are the optima conditions of soil moisture and temperature, but what effect defective conditions have. Thus want of water in the first stage of growth is said to mean short stalk, but not necessarily small grain; in the later stages water is essential for grain development.

What is the quantitative expression of this law ?

According to Warren Smith, American corn requires between 40 to 80 per cent. of the saturation value of moisture for its most favourable development, but exactly what will be the development of a plant which has, say, 40 per cent. of moisture in one month, 30 per cent. in the next, 20 per cent. in the next, 30 per cent. in the next, and so on ?

In particular, what in each stage of development is the minimum requisite to support plant life.*

* Leather's researches throw some light on this problem, Vol. 1, No. 8 of the *Memoirs of the Department of Agriculture in India*, page 146, which shows that for unmanured wheat, an increase of soil moisture from 10 to 20 per cent. increases the grain weight by about 80 per cent.

(*Continued on page* 102)

Plant development. To sum up, the method of correlation enables us to establish prediction formulæ of both sowings and yield, which represent with accuracy the effect rainfall has on the crops. They would undoubtedly be improved by considering the effect, in particular, of prices, crop rotation and temperature, and by incorporating all established quantitative laws as to subsoil moisture and plant development. Even as it is, the formulæ obtained in this paper have a definite practical value which modern statesmanship cannot afford to ignore.

Conclusion.—In conclusion I wish to express my thanks to the kindness of Dr. Gilbert Walker and Dr. Simpson in having most of the many coefficients of correlation calculated.

Between 10 and 20 per cent. the weight of crop increases nearly in a linear fashion with increase of moisture, but though in the case of unmanured wheat diminution of outturn might be linear down to zero moisture it is certainly not so for Leather's experiments in the case of manured wheat, and in particular it is important to know what happens with greater saturation than 20 per cent. Even this preliminary knowledge for a pot culture with a percentage saturation kept constant throughout the period of development, would give a function closely correlated with the actual yield.

DIAGRAM VI.

DONA CHARHDA (Rabi Crops Sown.)

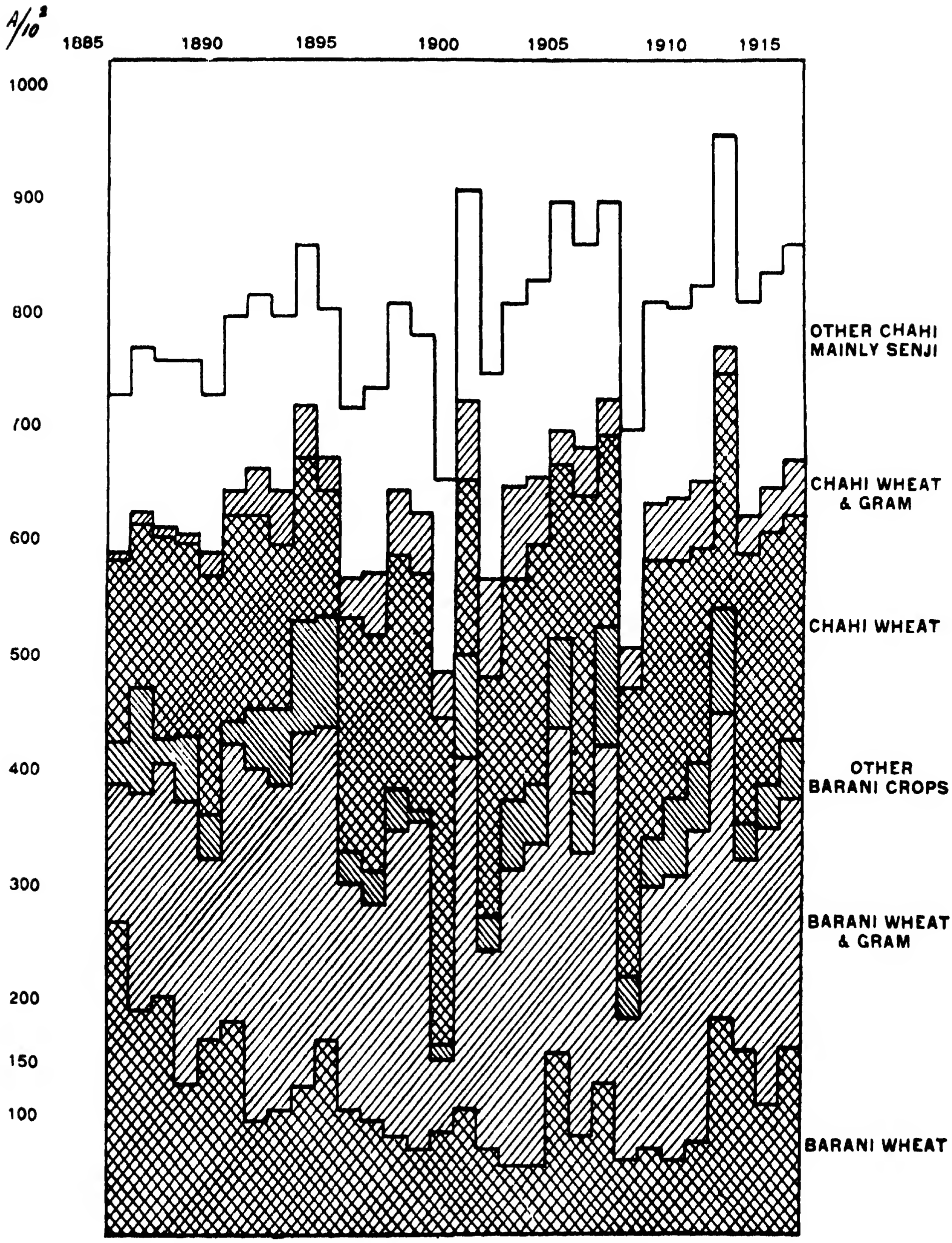


DIAGRAM VII.

Dona Charhda. (RABI CROPS SOWN)

PERCENTAGE OF EACH KIND OF CROP.

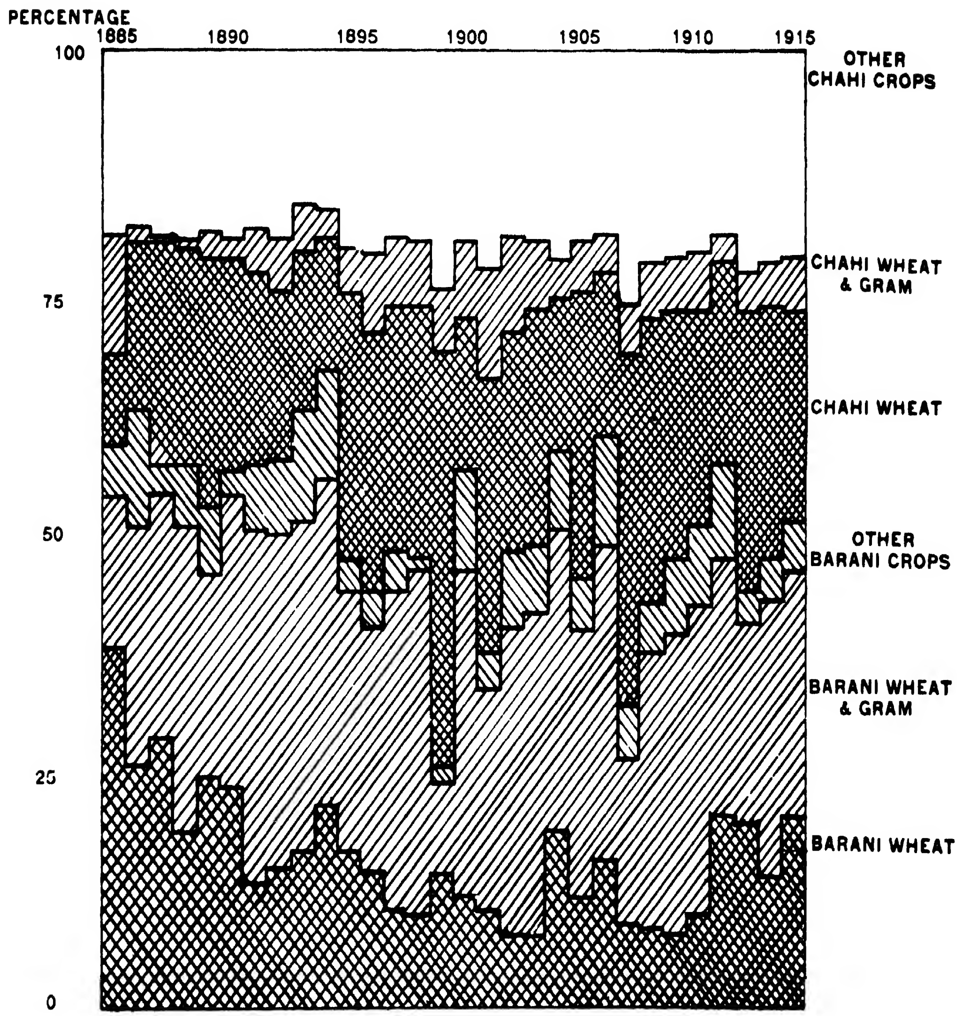
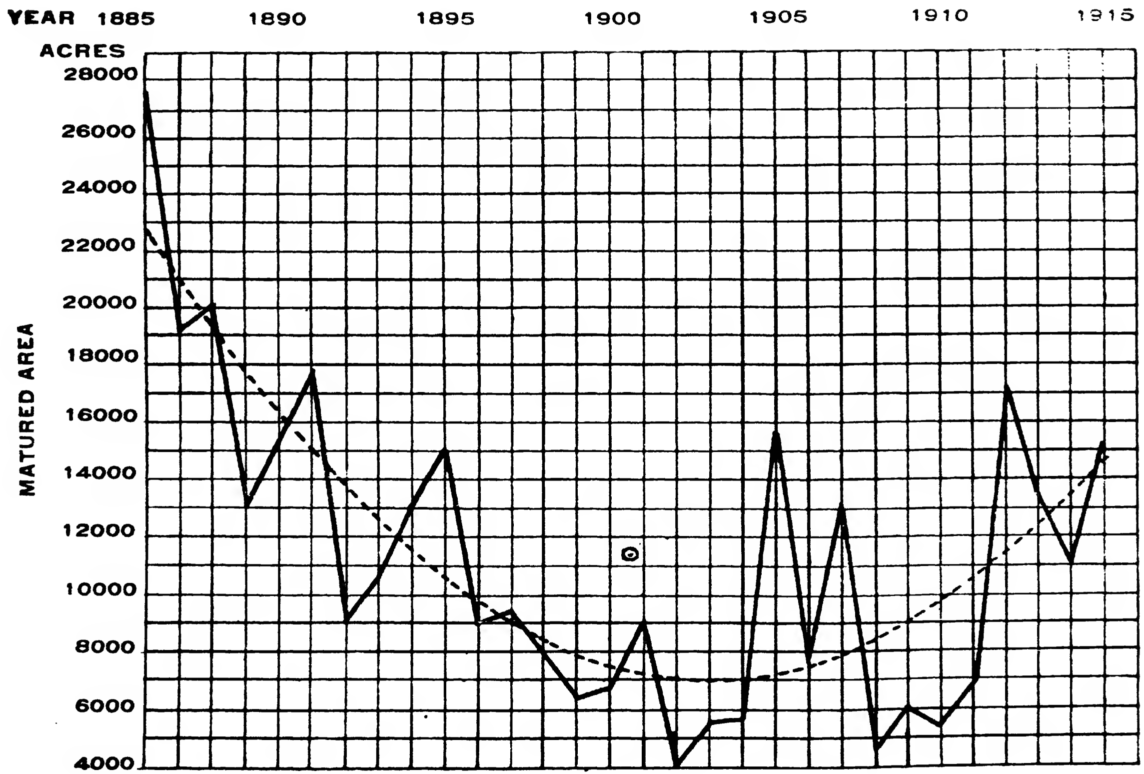


DIAGRAM VIII.

DONA CHARHDA CIRCLE JULLUNDUR TAHSIL

UNIRRIGATED WHEAT



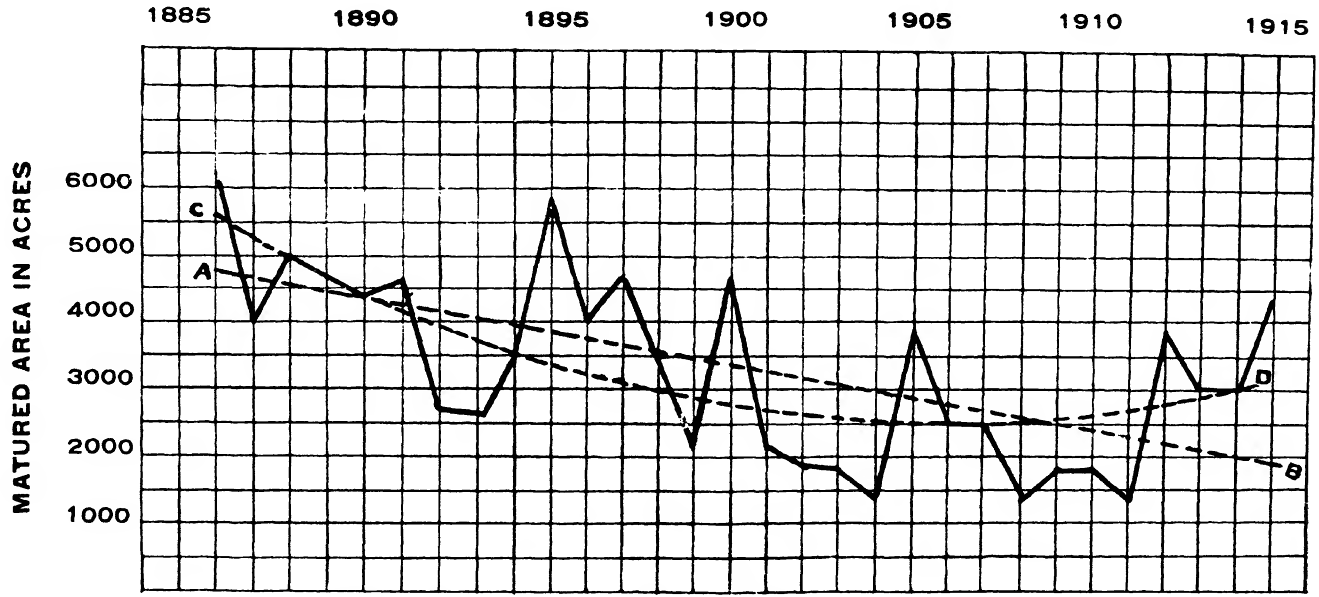
THE EQUATION OF THE PARABOLA OF CLOSEST FIT REFERRED TO THE CENTRE AS ORIGIN IS

$Y = -2{\cdot}01 - 0{\cdot}27X + 0{\cdot}108X^2$

DIAGRAM IX.

DONA LEHNDA CIRCLE JULLUNDUR TAHSIL

UNIRRIGATED WHEAT



AB IS THE STRAIGHT LINE OF CLOSEST FIT.
CD IS THE 2ND ORDER PARABOLA OF CLOSEST FIT.
THE EQUATION OF AB REFERRED TO CENTRE OF THE RANGE IS
$Y = -\cdot 20\ 2x$, AND OF CD. $Y = -\cdot 56 - \cdot 17x + \cdot 03x^2$.
THE LINE OF CLOSEST FIT IS EQUIVALENT TO A DECREASE
OF 100 ACRES PER ANNUM.

DIAGRAM X.

SIRWAL BARANI WHEAT.

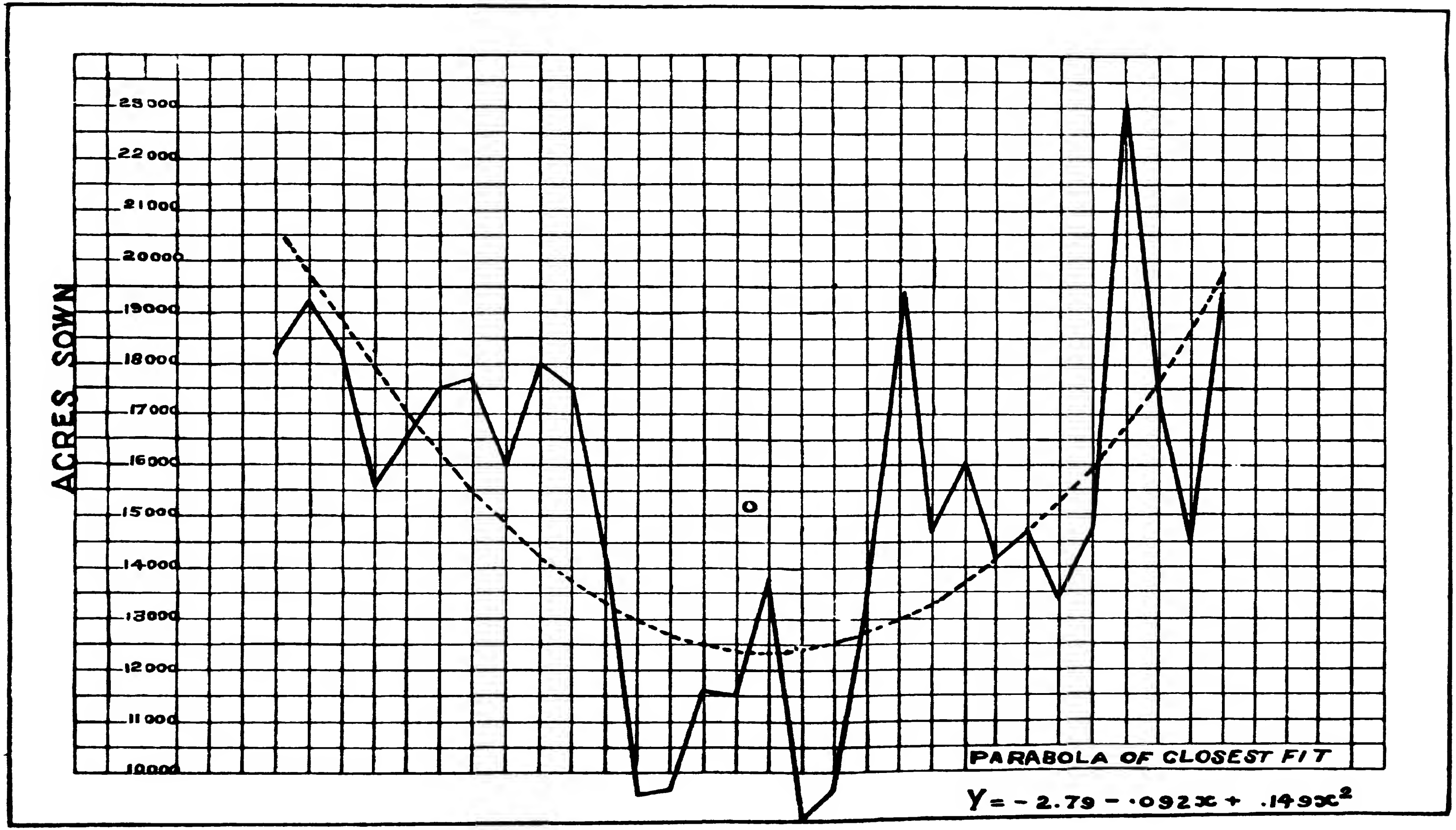
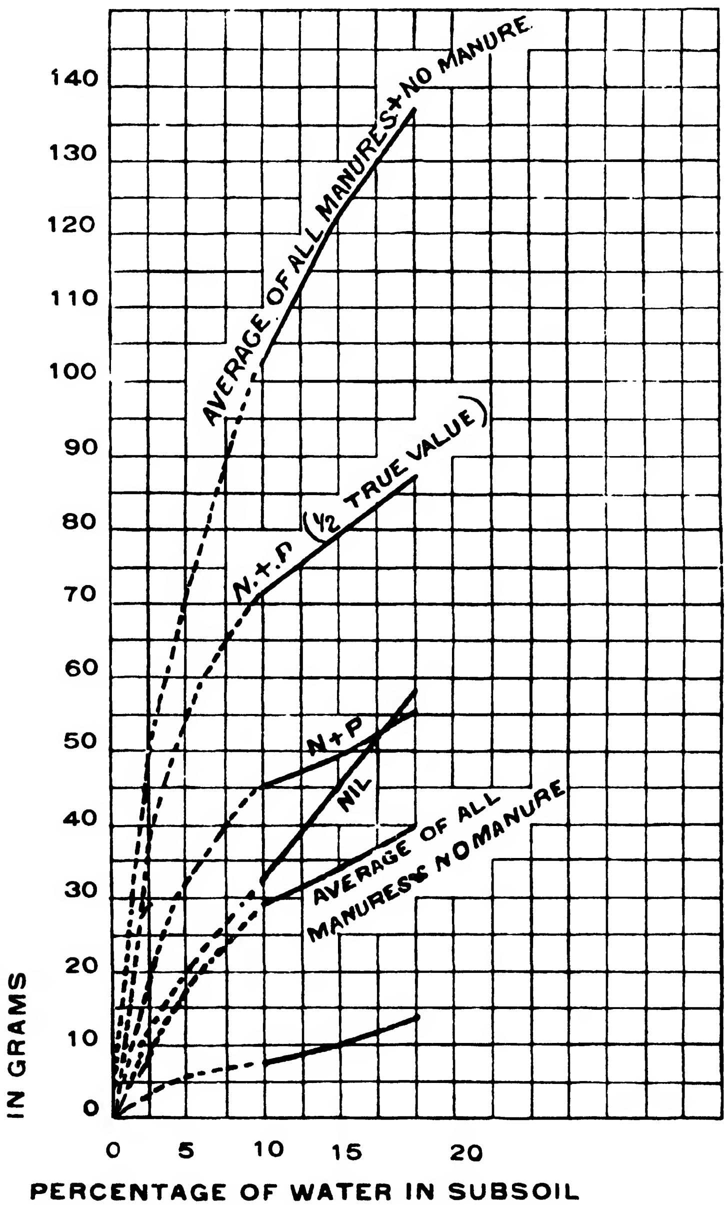


DIAGRAM XI.

EFFECT OF SOIL SATURATION ON YIELD OF WHEAT



N= CaCN2 P= SUPERPHOSPHATE
THE LOWER SOLID LINE IS THE AMOUNT OF SEED,
THE UPPER SOLID LINE IS THE TOTAL DRY CROP.
DOTTED LINES GIVE ASSUMED INTERPOLATIONS

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